Smith R.I.

WITH COMPLIMENTS OF
Flora W. Patterson
F. L. Stevens?

BULLETIN 206 MARCH, 1910

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE AND
MECHANIC ARTS

WEST RALEIGH

IMPERIAL BUREAU
13 JUL 1921
OF MYCOLOGY

INSECTS AND FUNGOUS DISEASES OF APPLE AND PEAR

General Card
Do not index each disease

Edwards & Broughton Printing Co.
State Printers

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS

THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. & M. COLLEGE

GOVERNOR W. W. KITCHIN, *ex officio* Chairman, Raleigh

C. W. GOLD.....Raleigh	M. B. STICKLEY.....Concord
E. M. KOONCE.....Jacksonville	T. T. BALLENGER.....Tryon
T. W. BLOUNT.....Roper	N. B. BROUGHTON.....Raleigh
D. A. TOMPKINS.....Charlotte	O. L. CLARK.....Clarkton
J. T. ELLINGTON.....Smithfield	EVERETT THOMPSON....Elizabeth City
W. E. DANIEL.....Weldon	R. H. RICKS.....Rocky Mount
W. H. RAGAN.....High Point	O. MAX GARDNER.....Shelby
W. B. COOPER.....Wilmington	LOCKE CRAIG.....Asheville

STATION STAFF

D. H. HILL, President of the College

C. B. WILLIAMS.....Director and Agronomist
W. A. WITHERS.....Chemist
F. L. STEVENS.....Vegetable Pathologist and Bacteriologist
J. S. JEFFREY.....Poultryman
F. C. REIMER.....Horticulturist
R. S. CURTIS.....Animal Husbandman
JOHN MICHELS.....Dairy Husbandman
R. I. SMITH.....Entomologist
G. A. ROBERTS.....Veterinarian
J. G. HALL.....Assistant in Plant Diseases
W. C. ETHERIDGE.....Assistant Agronomist
B. J. RAY.....Assistant Chemist
A. R. RUSSELL.....Assistant in Field Experiments
P. L. GAINEY.....Assistant Bacteriologist
L. R. DETJEN.....Assistant Horticulturist
F. W. SHERWOOD.....Assistant Chemist
A. F. BOWEN.....Bursar
C. P. FRANKLIN.....Secretary and Stenographer

The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
WEST RALEIGH, N. C.

INSECTS AND FUNGOUS DISEASES OF APPLE AND PEAR.

By R. I. Smith, Entomologist and F. L. Stevens, Pathologist.

The apple orchard industry in North Carolina is increasing yearly, and will continue to advance if those who are now engaged in the business place good fruit on the market. Already there are about one million apple trees in the State, but there is room for many times that number. The problem of securing land and location suitable to the growth of apples, is of course the first consideration, if profitable crops are to be secured, but of equally great importance is the matter of controlling the injurious insect pests and fungous diseases, which will undoubtedly appear soon after the trees are planted. An annual loss of from ten to fifty per cent, or more, in the value of the crop or the condition of the trees, is caused by insect pests and fungous diseases, where trees are not protected by spraying or some other tested preventive measure, when with proper treatment the loss of fruit or trees may be reduced to a small percent.

When a comparison is made between the wormy, scabby, disfigured, or rotting fruit so often offered for sale, and the beautiful specimens free from worms and blemishes which are seen in the best markets where they command a high price, the difference in price alone indicates which ones are profitable. The purchaser does not usually realize how many enemies there are from which the fruit grower must protect his apples or pears while growing, but the purchaser can and does appreciate good, sound, healthy fruit, and is willing to pay a good price for it.

The successful fruit grower should study and become acquainted with the orchard pests, which are discussed in this bulletin. After becoming familiar with the different forms, in connection with their life history and habits, a more intimate knowledge will come easily through experience and careful observation.

Among the insect pests, the most common and destructive forms are: the scale insects which occur on the limbs; the borers in the roots, trunk or limbs; the sucking plant lice on the roots or foliage; and the worms in the fruit. In addition to these the work of leaf-eating caterpillars and curculio should be mentioned.

Fungous diseases, such as scab, ripe rot, rust, leaf spot, hypochnose and black rot are, one and all, to be expected to injure the fruit or even to totally destroy it. Blight which is caused by a bacteria always commands a portion of the attention of the fruit grower.

These statements about orchard pests should not alarm any person who is thinking of planting an orchard, for even though all the

common pests and others also, have to be fought annually, there is good profit in apple or pear raising for the grower who will take proper care of the trees. The insects and diseases render constant attention and intelligent management necessary for profitable fruit growing. They afford opportunity for the intelligent, well-informed, vigilant orchardist to produce a crop of high market value, while they destroy the crops of the careless and ignorant.

In acquiring a knowledge of the more destructive orchard pests, with reference to cause, effect and remedial measures, the fruit grower will learn how to manage and prevent more than one trouble at a time. For instance, the spraying of apple trees with lime-sulphur wash in winter is a means of killing the San Jose scale, and also serves to kill the spores of fungous diseases which are living over winter on the bark, and also helps to control some insects besides the scale. Spraying in spring, just after the blossoms fall, with Bordeaux mixture and an arsenical poison serves to lessen the amount of wormy fruit as well as the scab, rust and other fruit and leaf diseases. Spraying in the summer to prevent apple rot and scab, serves also to cover the foliage with poison and thus kill caterpillars and other insects that eat the leaves.

There are many reasons, therefore, why a fruit grower should study all the principal orchard pests, rather than simply to learn how the San Jose scale, or apple worm, or apple scab, may be controlled. He should know how much real benefit results from careful spraying and other preventive measures. It is usually greater than most people suppose, and may mean all the difference between good profit and total loss.

I.—INSECT ENEMIES.

By R. I. Smith.

APPLE WOOLLY APHIS.

(*Schizoneura lanigera,* Hauss.)

The apple woolly aphids occur in damaging numbers principally on the roots, and are really responsible for the stunted, unhealthy growth, or even the death of hundreds of apple trees each year. In spite of this their presence often remains unnoticed except by orchardists who give strict attention to the condition of their trees. The extent of the damage must be far greater than is commonly supposed, when the number of infested trees in nursery blocks, together with those in both young and older orchards, is considered. In short, the woolly aphis is one of the most serious of apple pests, ranking with the San Jose scale and the apple worm.

ORIGIN AND DISTRIBUTION.

The original home of the woolly aphis is not definitely known, but they now occur throughout the world. In Europe the insects are known as the American blight on account of their supposed introduction on nursery stock from America. In the former country they are not a serious enemy to the roots of apple trees, but cause galls on the limbs and branches, sometimes so extensive as to kill trees, while in North Carolina and other southern states their injury to the roots of apple trees is of greatest importance. In the Northern States the aerial form, occurring on the branches, is more serious than the root form.

GENERAL DESCRIPTION AND INJURY.

The apple woolly aphis belongs to a family of insects including all the so-called plant lice which infest the buds and leaves of trees and plants during the summer months (for a description of the apple leaf aphis see page 65), but differ from most species in appearance, by secreting from their bodies a white, cottony substance, and they occur principally on the roots of apple trees. There is an aerial form of the woolly aphis which lives during late summer or fall on the trunk, limbs or branches, feeding usually in wounds made by pruning and in cracks and bruised places on the bark. Nearly all apple growers have seen these cottony masses, sometimes very small, but often extending a few inches along a crack, or wound caused by pruning off a limb. These masses, when examined, are found to contain numbers of brownish insects of various sizes, but none larger than a pin-head. The effect on the plant tissue takes the form of irregular galls which eventually become dead and dry, and, when

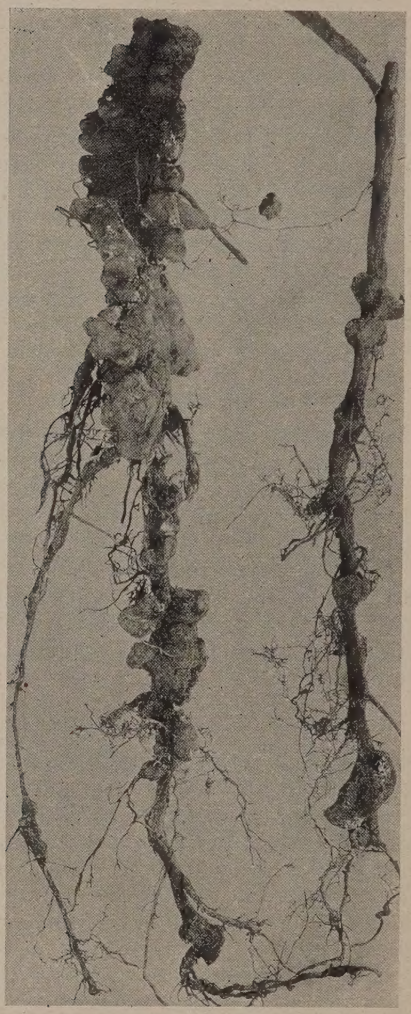

FIG. 1.—Woolly aphis galls on apple roots; specimens taken from a ten-year old tree. (About one-half natural size.)

this occurs, the insects migrate to other wounds or extend over a wider area.

Of much greater importance than the aerial form, there is the root inhabiting form of woolly aphis, which, by their feeding, cause abnormal swellings or galls, appearing like the illustration on page 46. The cottony secretion of the insects living on the roots is not always as white as it appears on the branches, although this covering is always present to a greater or less extent.

OUTWARD APPEARANCE OF INFESTED TREES.

The presence of woolly aphids on the roots may often be detected from the outward appearance of the trees. If badly infested they usually present a sickly appearance, indicated by the scanty foliage of a yellowish color and often a dwarfed growth. After the aphids have been present for two or three years the roots become so badly weakened that the entire tree may be easily loosened and pushed over; in fact, they are sometimes blown down by a high wind.

The colonies of the aerial form, on the branches during summer, or the galled areas where the aphids have occurred, are easily detected, and may be taken as evidence that the roots are infested.

FEEDING HABITS AND FORMATION OF GALLS.

Similar to all plant lice the woolly aphids subsist on the plant juices, feeding by means of piercing and sucking beaks. Wherever they feed galls of greater or less size are produced, the exact reason for which is not fully understood. It is due probably to some poison injected by the insects into the tissue of the plants.

The galls formed on the soft root tissue are large abnormal growths which soon commence to decay, their destruction being hastened by the entrance of fungi and bacteria. As the roots weaken and die the aphids die also, or move to other roots, so that when looking the first time, for signs of the woolly aphis, one may find badly injured roots from which the insects have all disappeared. By further search live aphids may usually be discovered on the few live roots remaining, or on close-by trees. The continual weakening and rotting of infested roots is what renders woolly aphis damage so disastrous. This drain on the vitality of the trees soon results in the characteristic, sickly (Fig. 2), dwarfed appearance as already explained.

DESCRIPTION OF INSECTS.

The form occurring on the roots—frequently called the apple root lice—and the aerial form, do not differ much in appearance. In reality they are of the same species.

The individual insects are reddish brown in color, but vary in size, depending on their age. The young are very small. Full grown

FIG. 2.—Woolly aphis injury to crown and roots of apple tree. Enlarged crown may be partially crown-gall. Original tree was twelve years old, only about eight feet high, showing stunted growth due to woolly aphis.

aphids are about one-tenth inch in length. A good idea of their appearance may be obtained by breaking through the cottony covering of a colony above ground and examining the aphids with a magnifying glass. Both winged and wingless individuals may then be seen. The cottony secretion arises from the abdomen of the insects, serving only as a protection. Its white color serves as a means of locating the aphids, particularly the aerial colonies. In fact, it is believed that the latter are beneficial, rather than otherwise, by serving to indicate that the roots of the trees are also infested, although woolly aphids sometimes occur on the branches without being, at the same time, on the roots.

LIFE HISTORY.

To understand the life history of a colony of woolly aphids for one year, it is best to first consider the forms occurring on the roots in mid-summer. Most of the adults are wingless, agamic females, each giving birth to living young at the rate of from two to twenty a day, until fully one hundred are born, after which the mothers die. They are really non-sexual, and their off-spring develop within eight to ten days into similar, wingless, non-sexual (agamic) females.

These wingless forms are most abundant during the summer. Later in the season some winged females develop, known as the migratory form. Some of them now desert the roots and fly to the limbs above, or to the branches of other trees, to start new colonies which are called the aerial form. These winged forms also give birth to living young which differ from their parents, by developing into true males and females. After mating, each female deposits one large egg in a crevice of the bark, where it remains until the following spring, when it hatches and develops into a wingless agamic form similar to the ones in the colony with which we supposedly started the previous year.

Some of the wingless aphids persist on the roots throughout the year in this state, remaining partially dormant during winter and resume active feeding and breeding the following spring.

Several generations occur each year which shows the necessity of killing the aphids during the spring months, for otherwise they increase to injurious numbers during summer and fall. The writer's experiments have shown that kerosene emulsion is a preparation that not only kills the aphids present at the time of treatment, but acts also as a repellent for several months, thereby furnishing a nearly perfect remedy.

REMEDIAL MEASURES.

Apple woolly aphids, whether occurring on the roots or above ground, are fought by applying some mixture which has a corrosive, penetrating or suffocating effect on the soft bodied insects. Kerosene emulsion or tobacco (in dry form or as a decoction) and potash or lye soap solutions are the most effective for this purpose.

The aerial colonies are easily destroyed by saturating them with twenty per cent kerosene emulsion (see formula page 50) or with a tobacco wash made by boiling the following for two hours:

Fresh tobacco stems or leaves	3 pounds.
Water (after boiling is over) to make	5 gallons.

This wash should be used full strength, preferably while warm, and may be applied with a brush, cloth, or spray pump, taking the precaution to see that the lice under their cottony covering are actually reached.

Previous to the year 1905 the root infesting form was fought principally by applying liberal quantities of tobacco dust or tobacco stems and leaves, depending on its decomposing and ultimately leaching through the soil so that the nicotine might kill or drive away the insects. This method is still in use in many places.

A number of experiments were made by the writer in Georgia during 1905 and 1906, to test the relative value of tobacco treat-

ments, whale oil soap solution, tobacco whale oil soap solution, kainit and tobacco, kainit alone, common salt, carbon bisulphid, and, particularly, kerosene emulsion at varying percentages. Those experiments demonstrated conclusively that kerosene soap emulsion, at ten and fifteen percent strength was much superior to all other treatments. During June, 1909, similar experiments were made on apple trees on the Station farm at West Raleigh, when the superior value of kerosene emulsion was again demonstrated. As further proof of its effectiveness several nurserymen have commenced to use it extensively for controlling the woolly aphis on their young apple tree stock.

KEROSENE EMULSION TREATMENT.

Stock Solution.

Kerosene (good grade)	2 gallons.
Common laundry soap or whale oil soap	1-2 pound.
Water (must be soft)	1 gallon.

To prepare: Dissolve the soap in one gallon of boiling water, then remove it from the fire and add two gallons of kerosene and agitate the mixture violently for ten to fifteen minutes. As the kerosene and soap solution combine a smooth creamy emulsion will result. This violent churning breaks the drops of kerosene into such minute globules that the soap is able to hold them in suspension.

A perfect emulsion may be obtained in ten minutes by using a small force pump, equipped with a nozzle having one-eighth inch discharge and pumping the mixture back into itself with considerable force. Emulsion properly prepared will stand several weeks without the kerosene rising to the top. When diluted it requires frequent stirring to keep a uniform mixture.

The stock solution may be diluted to the required strength by adding amounts of water as follows:

For 10 percent emulsion dilute with 17 gallons of water.
For 15 percent emulsion dilute with 10 1-3 gallons of water.
For 20 percent emulsion dilute with 7 gallons of water.

Application.—Fifteen percent emulsion is recommended for general use, although ten percent is often thoroughly effective, and even thirty percent emulsion did not injure the trees in the writer's experiments.

Early spring, after the apple trees commence to grow, is the best time to apply this treatment, for two reasons: First, because it is desirable to kill the woolly aphis at that time; and, second, because while the trees are growing vigorously the kerosene will not cause

injury. When the trees are dormant there may be danger that the kerosene will penetrate and injure the roots. Growers are advised not to use it during the winter or late fall.

Prepare the trees by removing the surface soil from around the trunk, to a distance of fifteen inches to two feet or more, and two to three inches deep, or enough to partially expose the infested roots. Then apply fifteen percent emulsion slowly until the soil is soaked to a depth of about three inches. The amount required per tree will vary from one to three gallons. Over four gallons have been applied, by the writer, to the roots of a tree having a trunk only six inches in diameter, without any sign of injury.

After treatment at once replace the surface soil.

The kerosene will reach and destroy all the aphids in the area treated, and the odor, lasting for two or three months, will act as a repellent against re-infestation by aphids from surrounding roots or from other trees.

This treatment should be given while the soil is in good workable condition, neither too wet nor too dry.

TOBACCO AND OTHER TREATMENTS.

Tobacco dust, applied in amounts of from two to ten pounds per tree, or strong tobacco solution, applied in the manner recommended for kerosene emulsion treatment, are claimed by many orchardists to be effective and to have the advantage of being a fertilizer also, but the writer has not found tobacco in any form equal to kerosene emulsion. Kainit or salt is of practically no value. Potash whale oil soap, or tobacco whale oil soap, used at the rate of two pounds to one gallon of water, in quantities of one to three gallons per tree, is partially effective, but very expensive and not equal to kerosene emulsion. Carbon bi-sulphid has a very limited value because it can not be made to spread through the soil without danger of injuring the roots.

TREATMENT OF NURSERY STOCK.

Nurserymen may treat rows of apple trees by applying ten percent kerosene emulsion in a shallow furrow opened on each side, using simply enough to soak around the infested roots.

Orchardists who purchase nursery stock may take the precaution to dip the roots in fifteen percent emulsion before planting to kill any woolly aphis which may be present. When a number of trees are dipped they should not be piled in large heaps, on account of the danger of the drip from the upper trees, running down and accumulating on the ones below, for while the trees are dormant there is some danger of kerosene injury.

ROUND-HEADED APPLE TREE BORER.

(*Saperda candida,* Say.)

Burrowing in the sapwood, and to some extent into the heartwood of apple trees, at, or near the surface of the soil, the round-headed borers sometimes cause severe injury before their presence is discovered. Young orchard trees and nursery stock are most commonly injured because the channels made by the borers cause a partial girdling effect. Two or three borers may kill a young tree while in older trees they may occur without causing serious injury.

The round-headed apple tree borers are quite injurious in the mountain section of North Carolina, but seldom occur in the central or eastern portions of the State.

The presence of borers is evidenced by an area of dried, brown, shrunken bark from which the sap exudes in early spring and sawdust like castings escape through cracks or are extruded by the larvæ from openings into their burrows. Infested trees may present a dwarfed appearance.

Apple and quince are the favorite food plants, but pear is sometimes attacked. Other trees that serve as food for this borer are: crab apple, thorns, mountain ash, choke berry, and June berry. Such trees should not be allowed to stand around apple orchards.

DESCRIPTION AND LIFE HISTORY.

The parent form is a beautiful beetle about three-fourths of an inch in length. The body is pale brownish yellow above with two

Fig. 3.—Parent beetle of round-headed apple tree borer. (About twice natural size.)

creamy white stripes extending the entire length of the body, including the head (Fig. 3). The beetles are nocturnal in habit. They appear during May or June and deposit eggs in cracks in the bark near the ground or on the trunk and main limbs.

The eggs hatch within two weeks into minute borers which immediately gnaw through the bark and commence to feed on the sapwood.

Borers are fleshy, somewhat grub-like, light yellow in color and cylindrical, with a dark colored head, not much wider than the body. The name, round-headed borer, is given to contrast this species with one closely related, in feeding habits, but possessing a wide, flattened head.

For the first season the round-headed borers confine their attack to the sapwood, making disc-shaped burrows which may reach the size of a silver dollar. At the approach of winter, the borers, as yet only partly grown, go to the lowest part of their burrow, and there remain quietly until the following spring, when feeding again commences. They then enlarge their burrows, extending them partly into the sapwood, and sometimes nearly girdle small trees. The second winter is also passed in the burrow. The third year of the borer's life finds them going deeper into the heart-wood, where, before late fall, they attain full growth, and then, with heads pointing toward the bark, transform to pupæ and remain so until spring. During May or June the pupæ change to beetles, which cut their way out and lay eggs for another generation.

The entire life of this borer covers nearly three years, most of that time being spent in the larval stage.

METHODS OF CONTROL.

The knife is the only certain remedy when borers are discovered in an apple tree. Cutting them out of the sapwood may be accomplished with rapidity and with only slight additional injury to the trees. Since it is known that the first season of this borer's life is passed in a small area of sapwood, and that the second year also is passed in comparatively shallow burrows, it is evident that careful annual inspection of trees and prompt removal of the borers discovered, will prevent serious injury.

Four or five borers often occur in one tree, some at times being located under the bark beneath the surface of the soil; hence when making a search for them the soil should first be pulled away. Round smooth holes, extending into the heart wood, indicate that the adult beetles have escaped, and when such are found open to the surface they may be disregarded, but if discovered underneath the dying bark it means that the full grown borer or pupa is present and can best be reached and killed by inserting a stiff wire.

Aside from the knife remedy, a preventive measure is sometimes adopted to keep the beetles from laying eggs on apple trees. This consists of applying to the trunk and main limbs a coating like whitewash, lime-sulphur wash, (see page 61), or a thick alkili soap solution; (Formula, page 57); or wrap the trees to a height of

eighteen inches with thick brown paper or newspaper, tied firmly at the top and dirt piled around the lower edge, and a deterrent wash applied above this protection. Trees should be covered in this manner from May 1 until August, and, when bands are used, they should be removed about September 1 and the trunk thoroughly scraped and wormed to remove any young borers which may have attempted to gain entrance.

It has been reported that the borers in their channels are killed by applying kerosene freely wherever their castings protrude through the bark. However, when an apple grower sees this indication of borers it would seem much safer and almost as easy to use a sharp knife and remove them at once, to be certain of victory.

FLAT-HEADED APPLE TREE BORER.

(*Chrysobothris femorata,* Fab.)

Compared with the round-headed borer, this species is of less importance, although often more numerous. They prefer to work in diseased or dying trees, but undoubtedly hasten or cause the death of trees injured by other insects, or affected by some fungous disease. However, they do not hesitate to attack apparently sound trees, and especially ones that have been recently transplanted, either in the nursery or orchard. Damage is caused by the borers making shallow burrows in the sapwood, similar to those made by the round-headed borer during its first season. The location of the burrows may be detected by the discolored, dried bark, which is often cracked and shrunken in appearance.

Flat headed borers enjoy a wide range of food plants, including apple, plum, pear, peach, oak, maple, hickory, chestnut, linden, willow and others. Besides, they also breed in newly cut timber.

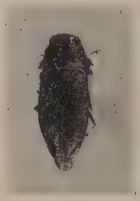

Fig. 4.—Parent beetle of flat-headed apple tree borer.
(About one and one-third natural size.)

DESCRIPTION AND LIFE HISTORY.

The parent form is a beetle about one-half inch in length, with a flattened, oblong body, tapering toward the posterior end (Fig. 4). The color above is greenish black with bronzy reflections while the

legs shine like burnished gold; the feet are shining green. These beetles commence to appear during May and persist for several months; they love the sunshine and may sometimes be seen running up and down the tree trunks.

The larval, or borer stage, when fully grown, is a worm nearly one inch long, lying normally in a curved position with the tip of the body close to the head. The segment of the body just behind the true head is much flattened and expanded, giving the appearance of a large flattened head, from which the name has been adopted. The feeding burrows never extend far into the heartwood, but are usually broad, shallow, irregular channels under the bark.

Concerning their life history, flat-headed borers reach maturity in one season, usually passing the winter in their burrows in the pupal condition. The parent beetles may be depositing eggs from May to August.

CONTROL MEASURES.

Apple growers should learn to detect the burrows made by both the flat-headed and the round-headed borers, and adopt the knife remedy when necessary. All statements regarding preventive measures given for the control of round-headed borers apply equally well to this species, except when using deterrent washes, it must be applied to all the largest limbs as well as the trunks of the trees.

Dead, dying or diseased trees, which may serve as breeding places for the borers, should be promptly burned, together with prunings from healthy trees. Such practice tends also to prevent the increase of shot-hole borers.

Orchards located near forests need frequent inspection, in order to remove borers before they cause severe injury.

SHOT-HOLE BORER OR FRUIT-TREE BARK-BEETLE.

(*Scolytus rugulosus,* Ratz.)

This borer belongs among a class with the flat-headed apple-tree borer because of being partial to weakened or dying trees, but nevertheless it is an orchard pest of no small importance. Damage to perfectly healthy trees is not great, but in every orchard there occur some trees which are weakened from various causes, and the shot-hole borers may hasten or cause their death.

It is only since 1877, when first discovered in New York State, that fruit growers have known of this pest. Since then it has spread to all the eastern states and at least as far West as Kansas.

In addition to the apple, nearly all orchard trees serve as food, particularly peach, plum, cherry, apricot, pear and quince. Early writers generally voiced the opinion that the shot-hole borer and its

larvæ would not work in a healthy tree. More recent observations, however, have shown that trees, to all outward appearances, perfectly healthy may be attached and weakened.

DESCRIPTION AND LIFE HISTORY.

The parent beetles are cylindrical in shape, very small, about one-eighth inch in length and only about one-third as broad. They are quite uniformly black in color.

The full grown borers or grubs appear larger than the beetles, measuring about one-sixth inch in length. In color they are pinkish white except for the brown head.

The winter is passed in the grub stage in shallow channels beneath the bark. In early spring the parent beetles mature and escape through small round holes scarcely one-sixteenth inch in diameter (Fig. 5). These beetles commence to bore into the bark at

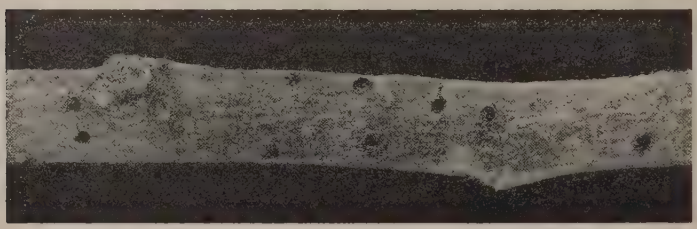

Fig. 5.—Shot-hole borer. Exit holes in apple twig. (Twice natural size.)

the base of buds or lateral spurs, and construct an egg chamber, sometimes an inch or more in length, on each side of which are deposited the eggs, which soon hatch into minute grubs that tunnel out at right angles to the main egg chamber. The grubs seldom make deep channels, but feed in the cambium or the sapwood just beneath.

Each female deposits about eighty eggs, hence their numbers may increase rapidly.

Three generations are likely to occur each year in this State, and when one considers that each beetle makes a hole to escape and another to construct an egg chamber, besides some holes made by the males simply for feeding purposes, one will realize how soon an infested branch may look as though the bark had been peppered with very fine shot.

REMEDIES.

As already explained these insects seem to prefer to breed in dying trees. Herein lies the clue to a remedy, or more correctly speaking, prevention. All dead and dying trees, broken limbs, and brush made by pruning, should be burned during winter or before March to

destroy all the young borers, which are living under the bark, and would otherwise change to beetles during early spring. If this advice is followed, except for the few beetles maturing from slightly infested trees, there can be none to reinfest the orchard the following spring.

The practice of using dead trees and limbs to fill gullies, or leaving them in piles around an orchard for several months before burning, can not be too strongly discouraged. In other words, do not leave dead wood or weakened trees in which the shot-hole borers may breed.

Fertilizers and good cultivation will assist slightly infested trees to recover, after the attacked portions have been removed, and the same is true for trees weakened through other causes. Healthy, rapid growing trees are better able, than poorly nourished, slow growing ones to withstand the attack of this or other insects.

Young grubs under the bark can not be destroyed by any known method except burning, but deterrent and poison washes have been used with some success, to prevent the parent beetles from boring into the trees to deposit eggs. A wash that has been used in the past is made as follows:

DETERRENT AND POISON WASH.

Dissolve as much common washing soda as possible in six gallons of water, and then dissolve one gallon of ordinary soft soap in the above and also add one pint of crude carbolic acid and mix thoroughly. To this add two pounds of lime slacked in two gallons of water, and finally add one-half pound of paris green or one-fourth pound of white arsenic and mix all thoroughly.

The above wash will poison some beetles if they attempt to eat through it. The trunk and large limbs of trees to be protected should be covered from the middle of March to mid-summer, requiring two or three treatments. In general orchard practice such work will hardly be profitable.

Wherever orchards are sprayed with lime-sulphur wash for the San Jose scale, it is probable that no other wash will be needed before mid-summer, or at least, additional treatment would not be practical, because of the expense.

APPLE TWIG BORER.

(*Amphicerus bicaudatus,* Say.)

This twig borer is an insect of small importance compared to many orchard pests, but is often present in apple orchards. It is a cylindrical beetle about one-third of an inch in length, of a chestnut brown color above, and black beneath. In early spring they bore into the small branches of apple, pear and cherry, entering just

above a bud and working downward in the pith, evidently for both food and shelter. Such twigs soon wither and their leaves turn brown.

The beetles do not remain long in these burrows, but leave in search of grape vines or green brier, where their eggs are laid and their young reared, in the dead or dying shoots.

Exemption from injury by the twig borer, will generally be secured when all neglected vineyards, wild grapes or brier thickets are not allowed to remain near apple orchards. The usual practice of pruning apple trees to remove all twigs injured by various agencies, is a necessary part of good orchard management and should not be neglected, although this twig borer usually deserts its burrow before such pruning can be made.

SAN JOSE SCALE.

(*Aspidiotus perniciosus,* Com.)

The San Jose scale is the most destructive scale insect in North Carolina. A great deal has been written concerning it, but in spite of this some orchardists are still unacquainted with this insect and its destructive powers. No fruit grower can afford to remain in ignorance of its appearance and remarkable ability to spread rapidly, nor the methods by which it may be controlled should it appear. There are yet in North Carolina some localities where the San Jose scale has not become established; but such places are not numerous and the scale has appeared or will eventually occur in all orchards. This insect is not confined to the principal orchard trees like peach, apple, pear and plum, but thrives on a great variety of trees and shrubs, including currants, roses, mulberry, osage orange and others that are grown in every locality. Apple and pear trees withstand the attack of the San Jose scale better than peach and plum, but even when the insects are not sufficiently abundant to injure the trees materially they may mar the fruit and lessen its selling value.

The name San Jose comes from the town in California where this insect was first discovered in the United States in the early seventies. Subsequent investigations have shown that its original home is Northern China.

DESCRIPTION.

The true appearance of the San Jose scale in its various stages can be detected only by the aid of a strong magnifying lens. When thus examined much variation between individuals will be noticed.

The scale of a full grown female is ashy gray in color, and almost round in outline; it shows in the center of the upper surface a prominence called the nipple surrounded by a darker colored ring (Fig. 6). The nipple is a characteristic of all scale insects belonging

a *b*

FIG. 6.—San Jose scale, on apple twigs: (*a*, one-fourth natural size; *b*, enlarged five times). Notice circular rings indicating individual scales.

to the same family; it is formed in part by the first molt or cast skin of the young insect; the subsequent scale formation is due largely to secretions from the body of the true insect beneath. The resulting scale is slightly conical, sloping evenly in all directions. Mature scales are about one-sixteenth of an inch in diameter.

The above is a description of the outward appearance of a female scale as it would grow under perfect conditions. When crowded on a branch they often assume widely differing shapes.

The hard scale conceals the body of the true insect. By using a pin or knife point the scale may be lifted, revealing the orange yellow body of the female.

The male scale differs from the female by being smaller, darker in color and nearly twice as long as its width. The nipple is at one end.

Young scales, when about two weeks of age, are almost perfectly round, nearly jet black, and show a prominent nipple surrounded by a grayish ring. They are no larger than a pin hole, but are easily recognized by the aid of a magnifying glass, and at this age are readily distinguished from nearly all other scale insects.

LIFE HISTORY.

Females mature at about five weeks of age and soon commence to give birth to living young, bringing forth two hundred to three hundred within two weeks, and then die. Eggs are never deposited by this species. Young crawling insects are minute in size, oval in shape and of a bright lemon yellow color. They crawl about for several hours in search of a suitable place to commence feeding by inserting their thread-like sucking beak, which is often longer than their body. After once commencing to feed their position is never changed, except in the case of the male which eventually becomes a tiny fly with two wings.

At the age of twelve days the first molt occurs when legs, eyes and antennæ disappear, and the insects under their scale covering then look like tiny flattened yellow balls. The sexes are not distinguishable. Six to eight days later a second molt occurs, and by that time the male scale has commenced to assume its elongated shape and at the age of about twenty-five days the two-winged insect escapes from under its scale covering. The females are about five weeks old when they commence to bring forth crawling young.

WINTER STATE AND HOW TO DETECT INFESTED TREES.

Winter is passed by the San Jose scale as half grown or nearly mature individuals. Mature males and females perish from exposure to the weather. During winter a badly infested tree presents a grey appearance, being about the color of wet ashes. Old dead scales may be closely packed together or piled on top of one another (Fig. 6). Among them will be found the black, circular, half-grown scales as described above. The greatest number of live scales will be found on the least thickly coated portion of the infested limbs and around the base of young shoots and branches.

A characteristic feature of the San Jose scale is that it causes the bark to turn red, especially on the young shoots of some varieties. Isolated scales may cause a blotch, in diameter, several times the size of the scale itself, and when such marks are found with the characteristic round, black or greyish scale in the center, it is good evidence that the true San Jose scale has been discovered. Other scale insects cause red blotches on the bark, but the scales themselves differ somewhat from the forms described.

REMEDIES.

Almost every conceivable material, having any claim to insecticidal value, has been tried to kill the San Jose scale. Whale oil soap solution was at first used with good success, but it has proved too expensive in general practice; kerosene and crude petroleum in mechanical mixture or as emulsions were extensively used in the

early fight against this pest, but are no longer considered safe and economical as a winter treatment; the so-called soluble oils, principally a mineral oil treated in a manner to render it easily mixed with water, have been, and are yet, used extensively, with reasonably good results; but the chief reliance is now placed on lime and sulphur preparations, which may be purchased, all ready and prepared to mix with water and be applied as a winter dormant tree spray, or some lime and sulphur wash which the fruit grower may prepare from materials readily obtainable, and use while the trees are not in foliage.

LIME AND SULPHUR WASH.

Formula.

Lime (fresh unslaked) ..... 20 pounds.
(Do not use a magnesia lime.)
Sulphur (flowers or flour of) ..... 15 pounds.
Water, to make ..... 50 gallons.
Boil for at least one hour.

Mix the sulphur into a thin paste with a small amount of water, and then add about fifteen gallons more in a kettle or whatever receptable is used for boiling. While this mixture is boiling hot add the lime which immediately commences to slake, causing violent ebullition. (The sulphur may be added to the slaking lime if preferred.) Stir frequently and add cold water, if necessary, to prevent its boiling over. After the lime is slaked continue to boil for at least an hour.

When properly prepared this wash is a dirty green color, *having lost the yellow sulphur color entirely,* but if allowed to settle a clear amber colored liquid appears on top. A residue settles quite readily, but as this is an important part of the mixture, it should not be discarded except that portion which is removed by the straining necessary to make the solution go through the ordinary spray pump nozzle.

The lime-sulphur wash is intended to be used only for winter spraying while the trees are dormant. It will burn the foliage severely, and, if used in summer, it should be applied only to the trunk and limbs. Badly infested trees should be sprayed twice during the winter, once in November or December and again in February; by this treatment the San Jose scale may be nearly exterminated. Trees only slightly infested are usually protected by one thorough spraying in February of each year.

COMMERCIAL LIME-SULPHUR PREPARATIONS.

Several brands of prepared lime-sulphur wash are now being manufactured and sold by different chemical companies. All reliable

concerns offering this preparation for sale have a mixture that is practically as effective—if used at the proper strength, usually one part to ten of water—as the home prepared wash, and most fruit growers will find it more convenient, and, in the end, just as economical to use one of them in place of the formula given above.

SUMMER TREATMENT FOR SAN JOSE SCALE.

Summer spraying is sometimes advisable when an orchard is discovered to be infested after the trees commence to grow, but dormant tree spraying, as recommended, is much to be preferred.

The lime and sulphur preparations may be used on the trunk and limbs, without injury to the bark, but foliage will not stand such treatment.

Kerosene emulsion at fifteen per cent strength (formula page 50) will kill a large percentage of the insects, if applied during the summer months. It kills all the young or partly grown scales, but does not usually kill the mature females. It can be applied with safety provided the emulsion is properly prepared and applied on a bright day, applying only enough to cover every branch and twig together with the foliage, without its running down and accumulating around the trunk.

OYSTER SHELL SCALE.

(*Mytilaspis pomorum,* Bouche.)

The oyster shell scale is widely distributed, but is not by any means as destructive as the San Jose scale. It has occurred in the United States over one hundred years, since being introduced originally from Europe.

Full grown female scales are fully one-eighth inch in length, slightly convex and usually curved in outline to resemble a minature oyster shell (Fig. 7). These hardened scales are brownish or grayish brown in color, closely resembling the bark of the tree on which they live, and the true insects live underneath. By lifting a scale the yellow, soft-bodied female may be seen during summer, but in her place, a number of pearly white eggs, during winter.

The scale covering of the male is shorter than the female, and little, if any, curved. The adult male is winged and appears in mid-summer to fertilize the females.

During winter the female scales cover a mass of pearly white eggs, which hatch during the latter part of April or May.

Two generations develop annually in the southern states, but only one occurs farther north.

FIG. 7.—Oyster shell scale, on apple twig. (Six times natural size.)

REMEDIAL MEASURES.

It has been found extremely difficult to kill all the winter eggs even by applications of strong kerosene emulsion, lime and sulphur wash, or strong soap solutions such as are effective against the San Jose scale which at that season are living as partly grown individuals. Twenty percent kerosene emulsion will penetrate the oyster shell scales and destroy some eggs; lime-sulphur wash or plain whitewash tends to loosen the scales and cause some to sluff off, thus exposing and killing some eggs, but winter treatment can not be strongly advised.

The most vulnerable period of the life history of this insect is just after the eggs hatch in spring; that is, while the young are crawling about, or soon after they have commenced to feed and secrete their hard scale covering. They are then susceptible to weak contact sprays, such as ten percent kerosene emulsion, common laundry soap, whale oil soap, or lye soap, dissolved at the rate of

one pound in five gallons of water. Apple growers should determine when the eggs hatch by watching infested trees after about the latter part of March in order to apply the remedy before the insects become protected by the hard scale covering.

In general practice it will be found profitable to prune off badly infested branches during fall or winter, at the same time marking such trees and others slightly infested, for treatment the following spring.

The above recommendations are applicable also to treatment for the scurfy scale insect.

SCURFY SCALE.

(*Chionaspis furfurus,* Fitch.)

The scurfy scale is more abundant in Western than in Eastern North Carolina. It occurs on both apple and pear, and is readily recognized, when present, by the whitewashed appearance it gives to the trees.

This insect is a native of America, its original home being on the bark of our native crab trees. In power of destructiveness it does not equal the oyster shell scale, and its injury is insignificant compared with the San Jose scale.

The scale of the female is about one-tenth inch long, very flat and irregularly triangular or pear-shaped in outline. The nipple is at the pointed end, which usually points upward. The color is light grayish or whitish, but seldom pure white.

Under this scale the female insect, when full grown, deposits a mass of eggs, in this respect agreeing with the oyster shell scale; but these eggs are purplish instead of white, and the little larvæ when hatched are reddish brown in color.

The scale of the male is pure white, much smaller than the female, and differs further by having parallel sides and three parallel ridges along the back. They usually occur on twigs separate from the females, giving some parts of the bark a whitewashed appearance. The adult male is a tiny winged fly.

Two and sometimes three generations occur each year. Winter is passed in the egg stage only. During April or May these eggs hatch into minute lice which crawl about for a short time, then settle down to feed and secrete the hard scale covering.

Remedial measures consist in pruning off and burning badly infested branches, or applying strong contact sprays during winter to loosen the scales and destroy the eggs beneath, or the use of weak spray mixtures on the newly hatched young which appear about the same time as the oyster shell scale. In fact all treatments suggested for the latter may be used to control the scurfy scale.

GREEN APPLE LEAF APHIS.

(*Aphis pomi*, De Geer.)

One of the most common and persistent pests of the apple orchard, is the green leaf aphis, which lives on the under side of the leaves, causing them to curl, blacken and die. Recently planted orchards and nursery stock are damaged annually, the result being a dwarfed, stunted, deformed growth, or occasionally the death of infested trees. Older trees are also attacked. Control measures are simple and effective when applied at the proper time, which is when the aphids first appear and before the leaves are badly injured.

DESCRIPTION, LIFE HISTORY AND HABITS.

The following description and life history notes are based largely on the work of Smith, of New Jersey, who has made a careful study of the insect.

Winter Egg Stage. The lice of the last generation lay eggs, and in this stage the winter is passed. The eggs are small, black, shiny oval-shaped objects, glued to the terminal branches around the base of lateral shoots or buds.

First Spring Generation. About the time the buds are bursting in spring the eggs hatch into minute insects, and, like all plant lice, they feed entirely on the plant juice, which is sucked through their slender beak.

Plant lice extract much larger quantities of sap than they can assimilate, which results in drops of liquid coming constantly from their bodies, either through the two honey tubes on the upper posterior end of the abdomen or through the anal opening. This liquid is highly prized by ants, which are nearly always found running over and around the aphis colonies. It is a great mistake to suppose that ants eat the aphids or injure them in any way; on the other hand ants often protect and aid some species of lice in return for the sweet liquid, called honey dew, of which they are so fond.

The honey dew is directly responsible for the black, sooty fungous growth which nearly always follows the appearance of the green leaf aphis. The fungus thrives on this honey dew, and soon clogs the breathing pores of the leaves, resulting in their turning brown, withering and dying. In this manner it may prove quite injurious to leaves not actually infested by aphids because such quantities of honey dew drop from aphis colonies to the leaves beneath.

Returning to the aphids just hatched from the eggs, it is found that they increase rapidly in size. Only fifteen days elapse before this generation becomes mature. Each adult is then known as a stem-mother, and is able to give birth to living young at the rate of eight or ten a day until at least fifty are born.

The stem-mothers are all wingless, bright green in color and somewhat pear-shaped, with a body one-twelfth inch long. They are agamic, non-sexual forms, giving birth to living young; true males not being present.

Second Generation.—Differing from the first generation, the second reaches maturity in eight to nine days. Some develop into wingless forms, like their parents, but about three-fourths show development of wings after the third molt. The wingless forms resemble the parents, but the winged individuals are slightly smaller and darker green, some almost black in color.

These winged aphids represent the migratory form, and fly to surrounding branches or other trees to start new colonies. Their young are also produced alive by non-sexual reproduction, as before, but all are again wingless. The wingless aphids of the second generation remain in the original colonies, and about one-half of their young mature with wings, and migrate to start more new colonies.

Third Generation.—The third generation under favorable conditions will number into the hundreds and thousands, both in the original colonies and in those started by the migratory forms. The method of reproduction continues as already stated, except that no more winged lice appear.

Last Generation.—After several generations during the summer and fall while no males appear in the colonies, the last one develops into true males and females, and the latter, after mating, deposit fertilized eggs which remain on the trees during winter and hatch and develop into stem-mothers the following spring.

REMEDIAL MEASURES.

Apple leaf aphids are quite readily controlled by contact sprays applied before the infested leaves curl badly. The spray must come in contact with the lice, and the curled leaves render it difficult to reach them. Arsenical poisons are useless.

Referring to the life history it will be seen that it requires fifteen days for the first generation to mature, and nine days longer before the winged adults of the second generation appear. During these twenty-four days the aphids are confined to the vicinity where the eggs hatched, but soon afterward the winged migratory forms establish new colonies on other branches or other trees. Growers should watch their apple trees and be prepared to kill the aphids when they first appear, or at least within one or two weeks thereafter, in order to accomplish the work before the aphids become numerous enough to cause the leaves to curl badly, besides preventing migration and establishment of new colonies.

Tobacco Decoction.—A tobacco wash, made by the formula on page 49, will kill all the aphids that it touches. A weaker solution is often effective. Young trees and nursery stock are most easily

treated by dipping the tips in a bucketful of the decoction. Larger trees must be sprayed.

Several commercial brands of tobacco extracts are offered for sale, and are about equally effective when used at the necessary strength.

Kerosene Emulsion.—This is prepared by the formula given on page 50; and when applied at a dilution of fifteen to twenty per cent it will undoubtedly kill all the aphids that it touches, although in actual practice tobacco decoctions give better results. Kerosene emulsion must be well emulsified, to prevent the oil from separating, and the mixture should be constantly agitated while being used; otherwise some injury to the foliage may result.

Soap Solutions.—Any strong potash laundry soap or soaps prepared especially for insecticide work are effective against apple leaf aphis. They are used at a strength of one pound in from three to six gallons of water, preferably warm. Either whale oil soap, tobacco whale oil soap, or naphtha soap, will be found more effective than common laundry soap when used at equal strength. A solution of home-made lye soap, one pint in four gallons of water, is also a satisfactory treatment.

APPLE TREE TENT-CATERPILLAR.

(*Malacosoma Americana,* Harris.)

Tent-caterpillars are widely distributed and familiar to most farmers, because they make themselves conspicuous by dwelling in colonies and constructing tents or nests in which they rest when not feeding. These nests are often made on apple trees, or on other orchard trees and frequently occur on wild cherry.

FIG. 8.—Tent-caterpillar moth—female (Somewhat enlarged.)

DESCRIPTION AND LIFE HISTORY.

The parent moths are of a dull reddish brown color, having a wing expanse of about one and one-half inches (Fig. 8). Males are smaller than females, and are also distinguished by having their antennæ more prominently feathered. These moths appear during the early part of June and lay eggs in a characteristic manner. The eggs are deposited on small twigs, in clusters, usually forming a complete encircling ring, containing from two to three hundred (Fig. 9). The

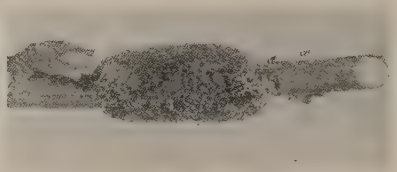

FIG. 9.—Egg-mass of tent-caterpillar. (Somewhat enlarged.)

eggs are conical, about one-twentieth of an inch in length and placed on end, side by side, in circular rows cemented together and finally covered by the female with a varnish-like substance which protects them during the eight or nine months that elapse before the eggs hatch the following spring.

The young caterpillars hatch early and feed upon the opening buds until the leaves expand. Soon after birth they crawl to the nearest fork formed by three or four branches, but usually within two to three feet of the old egg cluster, and there commence to construct an angular tent or web which is enlarged daily as the worms increase in size and require more room, until finally it may become one foot or more in length. The caterpillars leave the nest to feed two or three times a day, scattering over the tree in search of succulent leaves. They feed only in the daytime of bright days, and have the interesting habit of all leaving, and, later, returning to the nest at about the same time. On cloudy, or rainy days and at night, they remain in the nest. This habit enables the fruit grower to destroy the nest and its occupants without the use of poisons.

Tent-caterpillars attain full growth after feeding for five to six weeks; they are then nearly two inches in length; the body is blackish and hairy, with a continuous white stripe down the back and irregular short yellow lines along each side of this central stripe. A closely related species, the forest tent-caterpillar, has a broken white stripe along the back, and by that feature it may be distinguished from the species under discussion.

When ready to transform the caterpillars leave the trees and scatter in all directions in search of some suitable shelter under which to spin cocoons and pupate.

A cocoon is about one inch long, composed of yellowish silk woven closely inside, but loose outwardly and covered with a powder resembling sulphur. In this structure the chrysalis or pupa stage is assumed and lasts about three weeks, after which the parent moths emerge to mate and deposit eggs, as already described.

PREVENTION AND REMEDIES.

Fruit growers may easily learn to recognize the eggs masses (Fig. 9) on the bare twigs; during winter these may be removed and burned. In spring after the little caterpillars hatch and commence to construct their conspicuous nests every colony in an orchard may be located and destroyed. It should be remembered that this nest is used only as a shelter at night or when the worms are not feeding, hence its destruction must be accomplished while the worms are at home. This time is during the early morning hours, or about sun down, or on rainy days. People frequently make the mistake of burning with a kerosene torch, or otherwise destroying these nests during the middle of the day, with the result that few, if any, of its occupants are present, and the others of the colony, returning later, proceed to construct another nest.

Arsenical poison sprays, such as Paris green or arsenate of lead, used by themselves or with Bordeaux mixture, soon after the leaves expand, will prove an effective remedy by poisoning the caterpillars while they are small. Wherever regular sprayings are made with arsenicals to control the codling moth, apple trees can never be seriously defoliated by tent-caterpillars.

Colonies occurring each spring in wild cherry or other trees, should be destroyed in order to retard the natural increase of the species. The little work required to seek for and destroy them will prove to be time well spent.

FALL WEB-WORM.

(*Hyphantria cunea,* Harris.)

After the fruit grower has successfully routed the tent-caterpillars, his trees may become ornamented with large sprawling webs during June, July and August, and upon investigation these will prove to be the home of hungry, light colored, very hairy caterpillars which are continually extending their web to cover the foliage fed upon. These nests appear on many forest and shade trees as well as apple, pear and plum.

LIFE HISTORY AND HABITS.

The parent moths appear from June to August, coming from pupæ which passed the winter and spring in lightly constructed cocoons spun under the loose bark of trees, and other shelter above ground, or a short distance in the soil. Egg clusters (Fig. 10) con-

a *b*

FIG. 10.—Fall webworm: *a*, egg-mass somewhat broken; *b*, female moth. (Only slightly enlarged.)

taining from two hundred to five hundred eggs are laid on the under surface of the leaves. The young caterpillars devour the pulpy portion of the leaves, leaving the veins and under surface untouched, and spin a web over all the foliage that is fed upon. This web sometimes completely covers small trees and bushes before the worms attain full growth. When nearly grown they desert the web to wander aimlessly about, feeding on various plants before they finally discover a suitable shelter under which to spin cocoons and transform to pupæ.

Two generations occur each year, the first commencing in June and the second about two months later.

DESCRIPTION.

The parent moths are generally snowy white (Fig. 10), although some have dark spots on the fore wings which expand about one and one-quarter inches. The moths are active only at night.

Young worms are pale yellowish in color, sparingly hairy, with a double row of black marks along the back. Full grown worms are an inch in length, pale yellow or greenish as a rule, although some are darker; a black line extends along the back, while the body is clothed with tufts of long, straight dirty white hairs, often longest on the terminal segments. The worms drop quickly when disturbed, suspending themselves by a silken thread.

REMEDIAL MEASURES.

The appearance of webs on the trees is the first intimation of the arrival of fall web-worms. When these are seen apple growers may

know that the web and its occupants must be removed and burned, or else the foliage immediately surrounding the webs must be sprayed with an arsenical mixture to prevent further injury. The former method is quickest and certainly effective, and where only a few limbs are infested, as is usually true, it is cheaper to destroy the nest containing the worms than to spray the foliage surrounding them.

Orchards regularly treated with Bordeaux and arsenicals, as recommended on page 86, will not often need additional treatment to control this pest.

CANKER-WORMS.

(*Anisopteryx vernata,* Peck. and *A. Pometaria,* Harris.)

Two closely related species of worms that crawl with a looping motion, like measuring worms, occur at times in this State on both fruit and shade trees. In the worm stage they are almost exactly alike, but the parent moths differ somewhat in appearance and habits, particularly the females. The worms of both species burrow into the soil to pupate. The adult moths of those known as the fall canker-worms (*Anisopteryx pometaria*), emerge in late fall and deposit eggs which live through the winter, while the other species, *Anisopteryx vernata,* pass the winter as pupæ, emerging as moths the following spring, hence they are called the spring canker-worms. Eggs hatch at about the same time in spring which is when the apple leaves are unfolding.

DESCRIPTION.

The female moth of each species is without wings; her body is hardly one-half inch in length, and of an ashy grey color; her movements are slow and sluggish. Upon emerging from the soil the females crawl to the base of some tree, ascend the trunk, and there after mating, deposit broad, flat egg masses on the bark or in some crevice. Each mass may contain one-hundred or more eggs.

The male moths have well developed, brownish grey wings expanding fully one inch.

Full grown worms measure about one inch in length; their color is greenish yellow to dark brown; they do not construct a nest or web, nor live in colonies, like the tent-caterpillars or web worms; and they differ also by walking like a measuring worm. When grown they leave the trees by crawling down the trunk, or dropping by means of a silken thread, and while suspended in mid-air, often get on passing vehicles or pedestrians and are thus scattered over wide areas.

REMEDIAL MEASURES.

Canker-worms present a point in their development quite different from most insects; that is, the females, being wingless, must crawl up the trees to deposit eggs, or, should the young worms hatch near the ground, then they must ascend the tree to reach the foliage. For these reasons barriers that neither worms nor moths can pass, will, if placed around the tree trunks, serve as a perfect protection. Numerous things have been employed for this purpose, such as tree tanglefoot (same material used on tanglefoot fly-paper), printer's ink, coal tar, and other sticky substances, or bands of loose cotton or wool.

Tangle foot is a preparation used extensively in the gypsy moth suppression work in the New England States, and it has proved to be the best and cheapest sticky substance on the market. It may be applied to tree trunks without injury to the bark, and will remain for several weeks, sufficiently soft to catch and hold insects.

Bands of loose cotton may be used by tying them around the trunk, in such a way that the upper edges will hang down over the cord used for tying, so that the wingless females or young worms are entangled and held when they attempt to crawl up the trees.

Coal tar or printer's ink can not be used directly on the bark without danger of injury, although in the past they have been used to cover bands of paper or burlap, but such treatment is not advisable.

Apple growers will seldom have to resort to the above methods to prevent canker-worm injury, even should the worms become numerous. The usual practice of spraying trees two or three times each season with arsenical mixtures, will in most cases suffice to poison the worms before they are large enough to cause injury.

OTHER CATERPILLARS.

In addition to the ones already mentioned a few large species of caterpillars feed on apple foliage, but are controlled readily by the usual sprayings. Over a dozen different forms occur at times, but seldom, if ever, become numerous.

Small caterpillars, representing a wide range of forms and habits, which from their manner of feeding have been given such names, as, leaf rollers, leaf folders, leaf crumplers, apple leaf tyer, and apple leaf skeletonizer, at times become somewhat troublesome on trees which are not sprayed with arsenical poisons; but they can not multiply to injurious numbers where one or two sprayings are given after the trees are in foliage.

The larva of the eye-spotted bud moth is a caterpillar nearly three-quarters of an inch long, which feeds on the blossoms or newly formed fruit; sometimes they feed on the foliage and draw several

leaves together in a blackened withered mass. They may also burrow into the pith of the terminal branches. When such injury is observed the infested twigs or bunches of leaves containing the worms should be picked off and burned.

Another caterpillar with curious habits is the apple tree case-bearer. As the trees commence to grow in spring these little curved pistol-shaped cases, each containing a worm, may be found sticking to the fruit buds. The inside of fruit buds are first devoured; later the caterpillars transfer their attack to the foliage, where growth is completed, after which they transform to pupæ, and, during June and July the parent moths appear and lay eggs on the foliage, and the larvæ, hatching therefrom, feed on the leaves until late fall, when they attach their protecting case to some twig and remain dormant until the following spring.

Injury from all these smaller caterpillars is largely prevented, wherever apple trees receive the two or three sprayings with Bordeau mixture and arsenicals, which are necessary to control the apple worm.

CODLING MOTH OR APPLE WORM.

(*Carpocapsa pomonella,* Linn.)

The worms occurring so often in apples, and sometimes in pears, represent one of the most serious obstacles to successful apple raising. They are the young, caterpillar stage, of a small moth. Pears, peaches, plums, quinces and cherries have been found infested with this worm, although apples are their customary food.

The name applied to the parent form has been in use since 1747, when it was first employed by an Englishman named Wilkes. The name is now so common that nearly all apple growers use it when referring to the worm itself.

The annual loss attributable to the codling moth in the United States is estimated at nearly $12,000,000, or, in other words, about one-fourth more marketable apples would be raised were it not for this pest. The percentage of annual loss is greatest in the smaller orchards, owing to the usual neglect of the trees, when only a few are grown to furnish fruit for home consumption. In North Carolina where apple raising is a promising industry, although really in its infancy, the annual percentage of wormy apples is undoubtedly higher than the average for well managed orchards, and since it is well known that two annual sprayings with a suitable poison mixture will reduce the number of wormy apples to less than ten per cent, further arguments for the adoption of spraying are totally unnecessary.

LIFE HISTORY AND DESCRIPTION.

An intimate knowledge of the habits of the apple worm, regarding when and how they enter the fruit, in what stage they live through the winter months, when eggs are deposited, and other facts relating to their development, is necessary for a thorough understanding of the methods of control by spraying, banding, et cetera. Brief mention of each stage of development is therefore advisable.

Parent Moth.—The moths are seldom observed because they remain hidden during the day, and become active only about sundown or later. They are small moths with a wing expanse of not over three-fourths of an inch; their general color is brown, marked with gray; each front wing bears a dark brown spot near the tip (Fig. 11). When resting on the bark of a tree with wings closed, they

FIG. 11.—Codling moth: parent of apple worm.
(About twice natural size.)

are not readily seen. Shortly before dusk they commence to fly about the trees for the purpose of mating or laying eggs as described below.

Eggs.—Eggs for the first generation are deposited about ten days after the petals of the apple blossoms commence to fall, the exact date varying with the season. Each egg is about the size of a small pinhead and is pearly white when first laid, but assumes a darker color as the larva develops within. It is now known that over eighty percent of the eggs are laid on the upper surface of the leaves, while less than ten percent are placed on the young fruit and the remainder occur on the under surface of leaves or on the twigs. Each female is thought to deposit about fifty eggs, which hatch in from five to ten days.

Larvæ.—When first hatched the tiny worms commence instinctively to search for the fruit. Before careful observations had been made, it was supposed that most of the worms hatched on the fruit and entered at the blossom end, but now it is known that the majority hatch on the foliage, and a large percent never reach the fruit. The worms endeavor to conceal themselves, so that, when

once on the fruit nearly eighty percent crawl into the blossom end where they feed for a short time before burrowing toward the interior. Other worms commence to feed where two apples touch or where a leaf lies against the fruit, or they may feed for two or three days on the foliage.

Full grown worms are flesh colored and about three-fourths of an inch long; they have eight pairs of legs, and in this way may be distinguished at once from the plum curculio worms, which occasionally infest apples, because the latter are legless grubs. When inside the fruit, apple worms work mainly around the core, but when grown and nearly ready to spin cocoons they burrow directly toward the skin, usually to one side of the fruit (Fig. 12). This exit channel

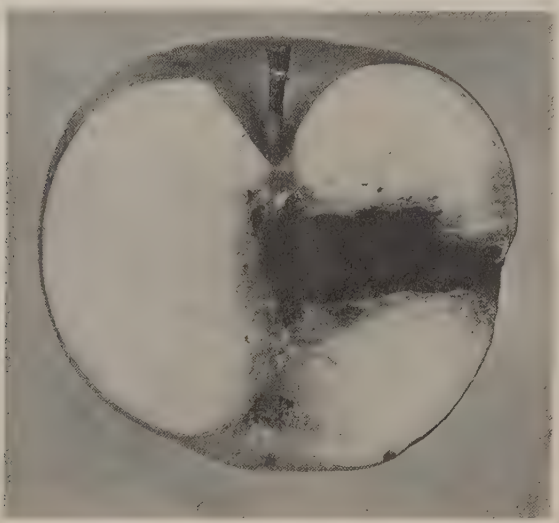

FIG. 12.—Apple worm injury, showing common condition of apples from uncared-for trees. (Somewhat enlarged.)

is plugged with particles of excrement for two or three days, until the worm is ready to emerge and seek a place to spin a cocoon and pupæ. They remain in the fruit from thirteen to forty days, depending largely on the weather conditions; those of the second generation mature more quickly than the first.

Cocoons and Pupæ.—After leaving the fruit, if on the tree, the worms may crawl down the limbs and main trunk, or drop to the ground by a silken thread and then ascend the tree in search of sheltered places under loose bark or in cracks and forks made by

large limbs, or they may seek shelter in some rubbish on the ground. The worms emerging from fallen apples may crawl up the tree or seek shelter elsewhere.

The cocoon is finally made to fit the crevice into which the worm crawls. It is composed of smooth white silk within, while on the outside the silk is mixed with particles bitten off by the worm in hollowing out a cavity for its body. In these cocoons the worms of the spring generation soon transform to pupæ, and, about two weeks later, emerge as adult moths; but the worms of the second generation usually remain in their cocoons all winter without pupating until the following spring, when the moths appear just after the apple blossoms fall.

Winter Stage.—The reader now knows that the worms hibernate in their cocoons during winter, but it may not be realized that these cocoons may be found wherever apples have been stored during the summer or early fall. Twenty or more cocoons may occur under a hoop of a barrel in which apples have been kept, while the cracks and corners of boxes or apple bins furnish excellent hiding places. When constructed under loose bark (Fig. 13) a large percent of

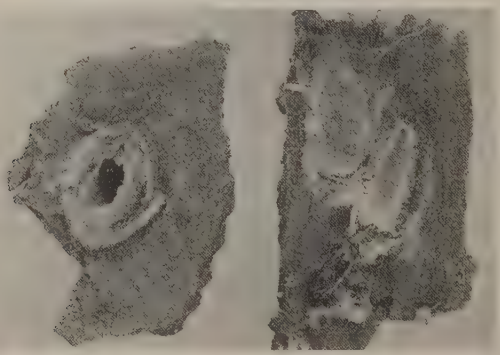

Fig. 13.—Cocoons of apple worm, constructed under bark of apple tree. (Somewhat enlarged.)

the cocoons are discovered by woodpeckers and other birds that consider the little worms as dainty morsels.

Generations.—Two full generations occur in this State; farther South there is a third; while in the North only one full generation develops each year. The first generation are grown and commencing to mature to adult moths about seven weeks after the apple blossoms fall, so that in case the fruit grower desires to spray to poison the larvæ of the second generation, as suggested under remedial measures, this time is reckoned upon unless the worms are in-

duced to spin cocoons under bands, where they may be examined frequently and the exact date of the emergence of moths determined.

REMEDIAL MEASURES.

Value of Spraying.—Spraying with arsenical poisons, preferably combined with Bordeaux mixture for the control of fungous diseases, is by all means the best remedy. The results obtained depend entirely on the applications being made at the proper time, and with sufficient care to cover the foliage and young fruit, in order to poison the worms during the first two or three days of their existence, that is, before they actually enter the fruit. This treatment is based on the fact that fully seventy-five percent of the young worms that hatch on the fruit, or reach it from the leaves, enter the

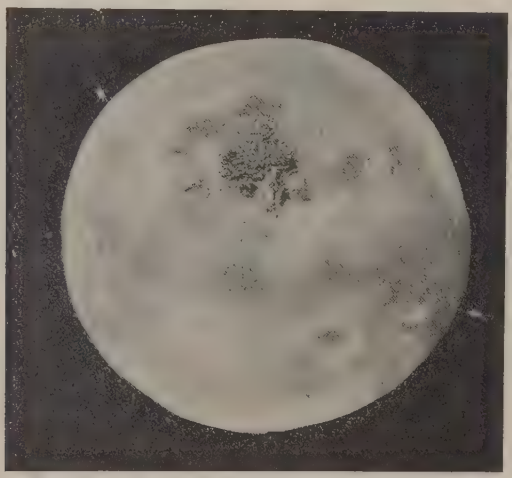

FIG. 14.—Apple worm injury in blossom end. This specimen was not inhabited by a worm when photographed, but shows how fruit may be ruined for market. (Natural size.)

calyx end (blossom end), and feed for a short time in the cavity formed by the calyx lobes where poison can be placed by thorough spraying just after the petals fall, but before the calyx lobes commence to close (Fig. 15). In other words, the principal effective spraying must be finished within ten days after the apple blossoms commence to fall freely. Where a large number of trees must be treated it is necessary to commence the spraying before all the petals have fallen, in order to complete the work before the calyx lobes close, but with only a few trees to be treated the first spray should be applied immediately after the blossoms fall. As this spraying

is of great importance against apple scab (page 87), it is best to spray while some petals are still falling.

For best results a second spraying with arsenical Bordeaux mixture should be applied one week after the first, although numerous experiments, conducted in different states, have shown conclusively that one thorough spraying before the calyx lobes close, will reduce the number of otherwise wormy apples, by nearly eighty percent. If both the first and second sprayings are applied at the correct time, it is often possible to secure from ninety-five to ninety-eight percent of apples, entirely free from worms.

Under some circumstances it is advisable to spray to poison the second generation, of which a large number of the larvæ enter the

Fig. 15.—Young apples showing, on left, calyx lobes open, and in right condition for first spraying; on right, calyx lobes closed, and almost, if not quite, too late for first spraying. (After Quaintance).

apples from one side instead of the calyx end; but the first spraying, applied thoroughly, is worth more—prevents more wormy fruit—than a number of similar applications after the apples have grown until the calyx lobes are tightly closed. The second generation of apple worms may commence to hatch about seven weeks after the date when the first spraying should be completed, which is approximately nine to ten weeks after the apple trees first commence to bloom. To the writer, it does not seem advisable to attempt spraying for the second generation, unless the grower is sufficiently interested to watch the development of the first generation, and thus know exactly when an application of poison will be most effective. Fig. 14 shows the work of a worm of the second generation, that could probably have been prevented by good spraying.

Arsenical Bordeaux Spray.—The most satisfactory spray mixture for codling moth treatment is prepared as follows:

Formula.

Blue stone	4 pounds.
Lime (must be fresh unslaked)	4 pounds.
Arsenate of lead	2 1-2 to 3 pounds.
or	
Paris green	6 ounces.
Water to make	50 gallons.

The blue stone and lime are combined to make Bordeaux mixture, by the method described on page 119. The arsenical poison, preferably arsenate of lead, is added to this and thoroughly mixed. The poison should be mixed at first in a small amount of water, and then added to the Bordeaux mixture.

How to Spray.—When spraying to prevent wormy apples the poison mixture must be applied as a rather fine driving spray, under high pressure, and directed primarily at the fruit, with the intention of getting some of the poison liquid in the end of each apple where the calyx lobes form a tiny cup. At the time this treatment is necessary the apples nearly all point upward, so that the calyx cup holds the liquid, provided the spray nozzle be set at an angle in order to drive the spray from the sides and from above, directly into the end of the fruit. When all the work of spraying is done from the ground, with the spray nozzle pointing upward, many apples will be touched on the sides while none of the poison will lodge in the calyx cup formed by the open lobes. All the foliage will be covered by the time the fruit is properly sprayed, and, in fact, the mixture must usually be applied until it drips from the leaves before thorough spraying is accomplished. The beginner will feel that a large amount is being wasted, and will be inclined to leave a tree before all the fruit is touched. It is poor economy to attempt to save material when spraying for the codling moth. One very thorough spraying is more effective than two poor ones.

Banding Trees.—The banding method consists of placing strips of burlap or similar material around the trunk and main limbs of apple trees to furnish a place for the worms to spin cocoons and pupate after leaving the fruit. It can not prevent injury by the first generation of worms. In practice the bands are placed around the trees within three weeks after the blooming period, and examined at least twice a week after the worms reach maturity and commence to leave the fruit. This inspection is continued as long as worms are caught in sufficient number to pay for the trouble. In some instances, when trees have not been sprayed properly, large numbers

of worms are trapped under the bands and are readily found and killed by crushing, but, as a means of securing fruit free from worms, in the opinion of most apple growers the benefit derived is not equal to the trouble and expense. An experiment conducted in Georgia by W. V. Reed showed that only about ten percent of the worms actually leaving the apples, are caught under bands placed around the trunk and main limbs; hence, even where trees have not been sprayed, a sufficient number of worms pupate elsewhere, and change to adults, to furnish a destructive second generation.

Disposal of Fallen Fruit.—Many of the apples that drop within one or two months after the fruit is first formed, are infested by apple worms, hence some method should be adopted to destroy such fruit in order to prevent the worms from becoming mature and leaving to spin cocoons and change to adult moths. Young hogs will do the work admirably, if they are not allowed too much other food and a sufficient number employed to keep the fallen fruit picked up clean each day.

Preventive Measures.—All rubbish, weeds, brush, or any material that offers a good shelter for the apple worms to spin cocoons, should be kept out of the orchard, or at least carefully cleaned up and burned during the winter. In this connection it should be explained that the trees themselves may be kept free from loose bark, and broken limbs, which offer hiding places for the worms. The lime-sulphur wash, as a remedy for the San Jose scale, tends to keep the bark bright and clean, and Bordeaux mixture has the same effect.

Other preventive measures, such as destroying the apple worms in their cocoons in boxes, barrels and bins where apples are stored, or having the storage rooms tightly screened to prevent the escape of codling moths which emerge from such places in spring, and scraping the loose bark off of old apple trees during the winter, will all help reduce the number of the first generation. Poison spray, as suggested, is really a preventive measure, because it kills the worms before they enter the fruit.

PLUM CURCULIO.

(*Conotrachelus Nenuphar,* Hbst.)

Apples and pears frequently show curculio injury, in the form of hard, knotty swellings on the skin of the half-grown or maturing fruit. The worm stage of the curculio is seldom found in these fruits on the trees, but is very common in peaches, plums, cherries or other stone fruits. The adult curculios have been bred, in some experimental work, from small apples that dropped before attaining one-fourth size.

DESCRIPTION AND HABITS.

The curculio is a small, dark-brownish, rough-backed beetle, only one-fifth of an inch in length (Fig. 16); the head bears a slender

FIG. 16.—Plum curculio: adult beetle. Notice long beak, on end of which are the biting jaws. (Enlarged six times.)

snout or beak fully one-third as long as the body; the small biting jaws are on the end of the snout; the beetles resemble a dried bud, when playing "possum" with legs and snout held tightly against the body, as they appear when disturbed. It is this habit, of which advantage has been taken, to jar the beetles onto sheets stretched under the trees, and at one time that was the best known method of fighting them.

The white, footless, grub-like worms commonly occurring in peaches, plums and cherries are the young of the curculio described above. The common apple worm differs by having eight pairs of legs, and is usually of a pinkish color.

During the winter months the adult curculios hibernate in some sheltered spot, emerging in spring about the time fruit trees are in bloom. They feed at first on the tender leaflets by eating small holes, but later they commence on the fruit, on which the eggs are laid in crescent-shaped punctures. Stone fruits are most acceptable, but apples are attacked if convenient. Both egg and feeding punctures are made in the skin of the young apples. If the egg hatches the worm usually causes the apple to drop within a short time afterward; some of the early drop may be attributed to this cause. However, most of the punctures develop into hard, knotty scars and spots which become noticeable when the fruit is about one-third grown, and are still evident when the fruit is gathered.

REMEDIAL MEASURES.

Apple growers can not afford to make any special fight against the plum curculio, except by such regular sprayings as are necessary for the control of the codling moth, and the practice of frequent shallow cultivation during May, June and July, as explained below.

Concerning the value of poison spray, it has been learned within recent years that a large percent of wormy peaches are prevented by spraying with arsenate of lead, and furthermore, wherever apple trees are well sprayed with any arsenical poison for the codling moth, the curculio injury is much less than on unsprayed trees.

The value of frequent shallow cultivations is due to the fact that the plum curculio larvæ go into the soil to form cells in which to pupate and transform to the adult beetles, but before this change occurs they remain under the surface for nearly three weeks, or sometimes longer, and during that time many may be destroyed by frequent cultivation, which is also most advisable for the health of the trees.

It is doubtful if an apple grower can afford to make any special effort to destroy the young fallen apples which may contain the curculio larvæ; but the usual method of gathering windfalls to destroy the common apple worm, will aid somewhat toward suppressing the curculio.

Whenever apple orchards are planted in among, or close by stone fruits, every effort should be made to suppress the curculio on the latter, by following the best advice, or information obtainable, and thus protect the apples from the chance of being severely disfigured by curculio. The writer can not use space here to discuss the treatment for curculio in peaches and plums.

APPLE CURCULIO.

(*Anthonomus Quadrigibbus,* Say.)

Very few apple growers in North Carolina have seen and recognized the true apple curculio, although it is occasionally present. The adult is a beetle somewhat similar to the plum curculio in general color and shape, but differs by being slightly smaller, and possessing a much longer snout; besides, it has a different manner of development. The plum curculio larvæ desert the fruit to burrow into the ground to pupate and transform into the adult stage, while this species passes through all its transformations in the flesh of the apple.

Concerning possible remedial measures there is little to be said. The apple curculio is not of much importance at present, but if it should occur in injurious numbers, some of the measures recommended against the plum curculio, will be found of value.

INSECTS INJURIOUS TO PEAR.

The pear industry in North Carolina has not been, in the past, sufficiently extensive to stimulate all growers into taking much interest in the insect pests, but as the orchards increase it will become necessary. The following insects, liable to injure pear, are discussed with the knowledge that none of them are of great importance in this State, with the exception of the San Jose scale, borers, codling moth and curculio.

BORERS.

The round-headed and the flat-headed apple-tree borers, the former discussed on pages 52-54, and the latter on page 54 are liable to attack pear trees, but they seldom prove as injurious as when working in apple trees. The remedial measures already advised are equally applicable for borers in pear trees.

The apple twig-borer is also an enemy of pear trees. It is discussed on page 57 with remedial suggestions.

PRIONUS BORERS.

(*Prionus laticollis,* Drury, and *P. umbricornis,* Linn.)

A large borer, often two and a half to three inches in length, is sometimes found in the base of a young pear or apple tree, or in

FIG. 17.—Prionus beetle. *Prionus laticollis.* (Natural size.)

the root of a grape vine. The borer in question has a heavy and prominently segmented body, yellowish white in color; the head is reddish brown in color and small, but provided with powerful jaws. It is supposed that this borer requires nearly three years to attain full growth, then changes to a whitish pupa, thence to the adult beetle.

The injury is peculiar in that the entire inside of the main root of a young tree may be devoured, while only a thin outer covering remains unbroken until the weight above breaks it over. Nursery stock, and occasionally young trees in the orchards are destroyed in this manner.

The borers of the two species named above resemble each other very closely, and the parent beetles are also much alike. They are large, powerful, brownish black beetles measuring from one and one-quarter to one and three-quarters inches; their heads are narrower than the thorax, and provided with strong jaws. Fig. 17 illustrates the general appearance of these prionus beetles.

There is no preventive measure to suggest, except to kill the borers and parent beetles when found. A young apple or pear tree is generally ruined by the time the borer is discovered.

SAN JOSE SCALE.

Some varieties of pears, particularly the Bartlett and Seckel, are often seriously injured by the San Jose scale, while the Keiffer, Le Conte and some of the hardiest varieties may sometimes grow in a peach or plum orchard where the scale is abundant without becoming infested or being injured in the least. However, this scale is usually a serious pest in mixed pear orchards, but it may be controlled by thorough spraying with lime-sulphur wash, and a study of the San Jose scale discussion on pages 58 to 62 will furnish the necessary information.

OTHER SCALE INSECTS.

The oyster shell scale, discussed on page 62, and the scurfy scale insect, page 64, are liable to occur on pear trees, although they seldom cause severe injury. In case they are discovered the remedial measures suggested will be suitable for treatment of the pear trees.

LEAF-EATING CATERPILLARS.

Pear foliage is subject to the attack of several different forms of caterpillars which may appear in early summer or fall. The fall web-worm, discussed on page 69, is an example, while several caterpillars of minor importance, such as, the tussock-moth caterpillars, the red-humped apple tree caterpillar, and the bag-worms may be present. In all cases of caterpillar attack no damage will occur if arsenical poison sprays are employed. Arsenate of lead at a strength of three pounds in fifty gallons of water or Bordeaux mixture is a safe treatment. Paris green at the rate of one ounce to ten gallons of spray mixture is also effective, but is washed off of the foliage by rains more quickly than the arsenate of lead. The

sprayings with Bordeaux mixture necessary to prevent leaf diseases, will also control practically all caterpillars, if arsenical poisons are added.

CODLING MOTH AND PLUM CURCULIO.

Pears are less liable than apples to be found wormy, but the worms which do occur are generally the larvæ of the codling moth, or in other words, the apple worm. Since this pest is fully described and remedial measures explained on pages 73-80, it needs no discussion here. Pears should be sprayed at the same time, in relation to the blooming period, and in the same manner as apples, to prevent wormy fruit.

The plum curculio may cause blemishes, and hard spots on the pear as well as on the apple. This form of injury, as well as remedial suggestion, is explained on page 80, to which the reader is requested to refer.

PEAR-LEAF BLISTER-MITE.

The blister-mites are minute creatures—more like spiders than true insects—that live in blackish blisters on the leaves of pear trees during summer and fall. When abundant they weaken the tree and reduce the crop.

Life History and Habits.—The mites appear on the leaves as they are unfolding in spring, and form red spots or blister-like galls, which have small openings on the under side of the leaves. Eggs are laid within the galls and the young escape through the opening and start new galls. As the season advances the blistered areas change from red to blackish in color, and in the autumn the mites leave the galls and locate in the outer scales of the winter buds, where they remain until the following spring.

Remedies.—The use of lime-sulphur wash (page 61), while the trees are dormant, will destroy nearly all the mites wintering in the buds, as explained above. Twenty percent kerosene emulsion (page 50), applied during the winter, is also a good remedy, but advisable only in case a pear orchard has been badly injured by the blister-mite, and where no San Jose scale exists, to require the lime-sulphur spray; in other words, the latter is the best remedy, as the mixture has a fungicidal value also, without any possibility of causing injury.

GENERAL SPRAYING RECOMMENDATIONS.

The fruit grower should have a clear idea of his reason for spraying, based on a study of the insect enemies, previously mentioned, and the fungous diseases discussed in the following pages; but when commencing he may be guided by the following:

First Spraying. Before leaf or blossom buds open, using lime sulphur wash (page 61), if San Jose scale are present or suspected; or with Bordeaux mixture of (4-4-50) formula (page 119). The lime-sulphur wash has the combined advantage of killing the San Jose scale and other insects that hibernate on the trees, and being nearly equal to Bordeaux mixture in its fungicidal effect.

Second Spraying.—Immediately after most of the petals fall, using arsenical Bordeaux mixture (page 79) for codling moth, bud worms, caterpillars, or apple scab and other fungous diseases.

Third Spraying.—Within one week to ten days after second treatment and using the same mixture; for codling moth, caterpillars, apple scab and other fungous diseases.

Subsequent Sprayings.—All sprayings made after the above, should be applied for a special purpose, such as treatment for the second brood of codling moth; additional sprayings to control the apple scab or leaf spot; or for the control of apple bitter rot; and possibly to destroy unexpected insects like fall web-worms, apple lice, and other forms. A fourth, fifth and sixth treatment is suggested on page 110 for control of apple diseases, and such sprayings are usually profitable if applied for a specific purpose. Arsenical poisons can always be used with Bordeaux mixture, or with the other fungicides mentioned on pages 119 to 123.

II.—FUNGOUS DISEASES OF THE APPLE.

By F. L. Stevens.

Original illustrations by
J. G. Hall.

THE APPLE SCAB.

(*Venturiose*).

This disease, collected in North Carolina by Curtis as early as 1867, is prevalent in all sections and is so well known to all apple growers as to need no description. Its general characters are well shown in Fig. 18.

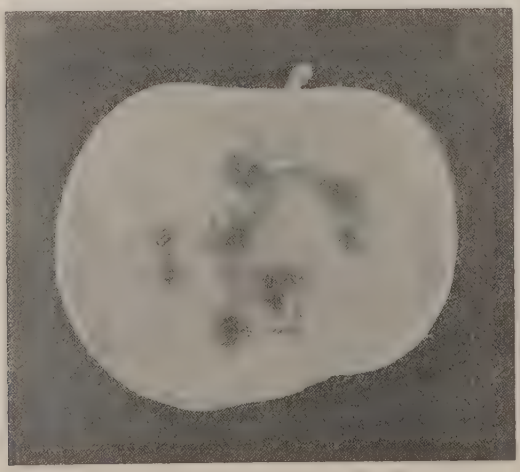

Fig. 18.—Apple scab.

The scab is caused by a parsitic fungus, which does great damage to the leaf as well as to the fruit. The spores, carried by the wind, fall upon the surface of the fruit, leaf or twig and there begin to grow, spreading from the central point of infection. Thus the diseased area is usually circular in outline. Upon the fruit the fungus grows between the skin and the underlying tissue and robs the growing parts of nourishment, causing the diseased regions to grow more slowly than other parts of the fruit. If scab occurs upon the stem of the apple, it so cuts off the supply of nourishment from the young fruit as to cause it to fall prematurely. Similarly the presence of the fungus on the stem of the leaf may cause the death of the leaf. As the apple approaches maturity, the scab, if very abundant, dwarfs one side, giving the fruit a lop-sided appearance, which

is quite characteristic. Owing to the premature falling, many apples affected most seriously with the scab escape observation.

Not only does this fungus damage the fruit, but it is also oftentimes present to a very serious extent on the leaves, where it causes a crinkling and an irregular ruffling accompanied by an olive discoloration. Here it interferes greatly with the proper accumulation of nourishment and results in a poorly fed tree the following year The failure of the apple crop can often be traced to poor nourishment the previous year, due to the presence of the scab fungus on the foliage.

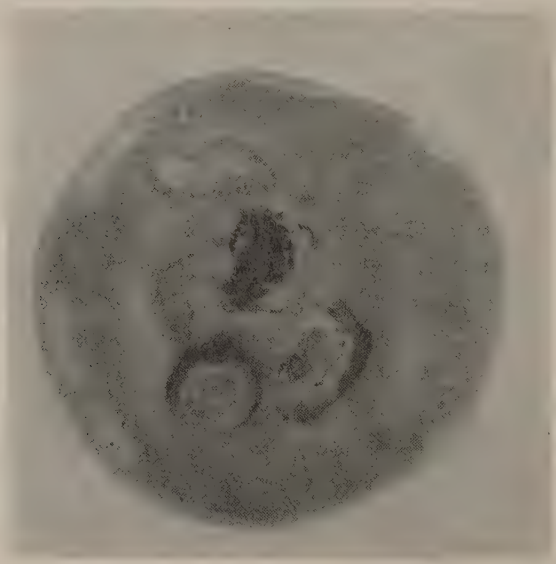

FIG. 19.—Apple scab followed by pink mould. This mould gains access through injuries in the skin caused by the scab. This apple is also suffering from injury by the worm of the codling moth.

While there is serious loss to the apple grower through the attack of the scab fungus upon the leaves and through the premature fall of apples directly traceable to the scab, the presence of the scab upon the mature fruit itself is probably the most serious injury. As was stated above, the diseased area develops poorly. Many scabs on the apple thus result in a marked diminution in the size of the fruit; but more important than this is the unsightliness of the diseased apple, which falls considerably below perfect fruit in market value. Examination of apples in the bin in winter or spring shows further that in many cases the scabby regions rest in the center of the rotten portions. In fact, the scab so destroys the skin of the apple as to permit the entrance of other fungi which cause soft

rot. Frequently whole barrels may be found in which every apple is scabby and nearly every scab is surrounded by a rotten area, varying in diameter from one-fourth to one inch or more, and eventually involving the whole fruit. In such apples the rot owes its presence to the scab, which prepared a way for its entrance into the otherwise healthy fruit.

Treatment.—Apple scab can be prevented by spraying with the Bordeaux mixture. It is advisable to spray from two to four times, according to the season. The first application should be made just before the buds open, followed by a second application when nearly all of the blossoms have fallen. A third application should follow eight or ten days later. Winter spraying on the dormant wood, if the ground be soft, may result in injury to the roots by the wheels of the sprayer.

The Bordeaux mixture should be made of four pounds of copper sulphate, four pounds of fresh lime (avoid air slaked lime), and fifty gallons of water. With the second spraying add six ounces of paris green or two and one-half pounds of arsenate of lead to every fifty gallons of mixture, in order at the same time to prevent damage from the codling moth. (See page 73.) Probably the Bordeaux mixture does not kill the scab when it is once upon the leaf or apple. Its chief value lies in *preventing the attack,* and in checking the spread. It should therefore be used early, placing all value upon prevention and expecting no actual cure.

One apple grower reports an increase of one thousand dollars in product from spraying, at an outlay of between $125 and $150. In the single State of Illinois, the apple scab is estimated to have caused $6,000,000 damage in one year, or 60 per cent of the total loss to the apple crop through all enemies. The value of spraying is brought out clearly in the following table, which presents results obtained in Missouri:

	Sprayed	Unsprayed.
Clean	83.5	33.6
Scabby	16.5	66.4
Salable	92.9	69.0

BLIGHT OR FIRE BLIGHT.

(Bacillose).

The blight, while one of the most serious of pear diseases is much less injurious to the apple, although even here it oftentimes does great damage, frequently causing dead spots on the trunks of the trees and blight of the succulent branches and twigs.

Upon the twigs its presence may be recognized by the blackening of the bark and the wilting of the leaves as though stricken by fire.

In the winter the diseased twigs are rendered very conspicuous by the retention of the withered leaves long after the healthy leaves have fallen. Very great damage also often occurs to the blossoms. The crab varieties are especially susceptible.

This disease, being pre-eminently a pear disease, is discussed more fully under pear. It may be said here that the disease is caused by a germ belonging to the great group of bacteria. These germs are extremely small and multiply with very great rapidity.

Under ordinary conditions, the disease is spread largely by insects which visit the blighted twigs for the sweetish liquid found on the bark. The insects then fly to another twig or blossom, bearing the germs with them.

Treatment.—The remedy consists in removing and burning all of the diseased twigs. In doing this, great care should be taken to cut low enough to insure the removal of all germs. The limit of the diseased portion can generally be told by the blackening of the bark, but it is usually best to cut a full foot below the diseased part, to avoid all possibility of leaving germs behind. It is also well to dip the knife in a solution of carbolic acid each time, before cutting into new twigs, otherwise, perchance, germs may be left on the knife to be transferred with the next cuttings to other twigs. Dipping the knife in five percent carbolic acid precludes any such possibility.

The best time to trim for the fire blight is in the early spring, when the new wood is succulent and green. At that time the leaves and young shoots affected by the disease may be readily recognized. Careful and thorough trimming during the early spring and summer will prevent the greater part of the blight, but close attention should be given weekly through the remainder of the year to hold the disease in check. In cases where large branches are removed and much surface exposed, the wound should be sealed, either with a grafting wax or with oil shellac, to which has been added a little flowers of sulphur and a few drops of carbolic acid. This mixture may be applied with a paint brush.

It is a matter of common observation that trees in rich soil, which grow too rapidly, are more often affected by the fire blight. This is due to the fact that in such conditions the twig is more succulent, and hence less resistent to invasion by the germ. The fire blight also affects the pear, hawthorn and service berry, and these must all receive attention in order to eradicate the pest. (See Pear, page 111.)

HYPOCHNOSE.

This disease affects the apple, pear and quince. It has been frequently referred to the experiment station for diagnosis and treatment, and seems to be one of the worst diseases occurring on neglected trees in the humid portions of the State.

Viewed from some distance, trees in early stages of hypochnose appear much as do trees affected with the ordinary blight (bacillose), that is, the leaves on numerous twigs throughout the trees are dead. The resemblance is very striking and to the casual observer hypochnose would doubtless pass for the widespread well-known fire blight. Differing from blight, however, the leaves, instead of standing erect, usually droop, hanging down in dense, matted masses. The affection too, is limited to the leaves, the twigs themselves not dying as in the case of the blight.

In later stages of the disease most of the affected leaves fall away and the similarity to bacillose disappears, the tree now attracting attention chiefly by its scant equipment of leaves. Closer inspection of the twigs with the affected leaves shows each to bear two characteristic structures:

1. Roundish or oblong sclerotia usually 1-8 to 1-6 inch in diameter. These are clearly shown natural size on the left-hand branch in figure 20, and somewhat enlarged in figure 21.

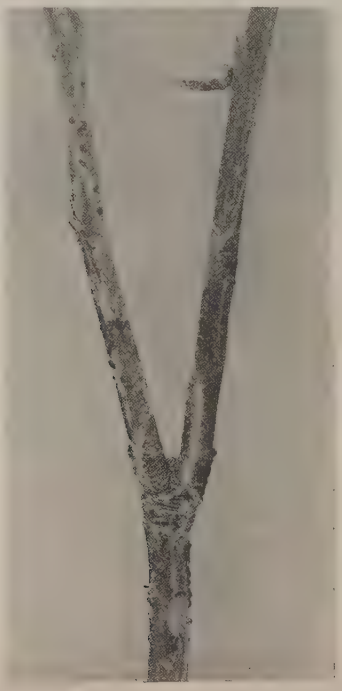

FIG. 20.—Hypochnose sclerotia and mycelial ribbons upon apple twigs. (Natural size.)

2. Mycelial ribbons, extending lengthwise of the twigs and petioles (Figs. 20 and 21).

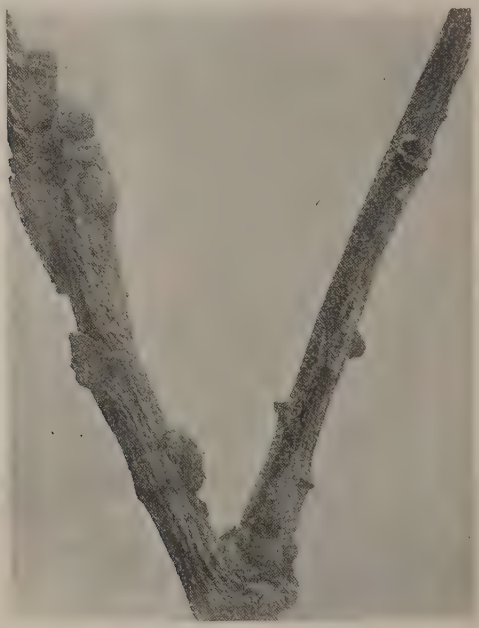

FIG. 21.—Hypochnose sclerotia on apple twigs. (Enlarged.)

These last when young are white, but as they age they rapidly assume a characteristic glistening brown appearance. They extend in a general longitudinal direction, and usually remain unbranched between the nodes, though they sometimes branch and form a network. Occasionally branches diverge to courses leading around the twig. At the base of each small twig the ribbon usually branches, a portion of it passing onto the smaller twig.

Branches of these mycelial ribbons also follow up the stems and the main veins of the leaves, eventually spreading out, separating into single threads and becoming lost to the naked eye. The mycelial ribbons on the older wood die and often weather away, though they adhere with considerable persistence.

Upon the under surface of affected leaves may be found, usually, a more or less dense net of fungous threads. In some instances this weft consists of a dense mat of threads, white or smoky, according to their age (Fig. 22 lower lefthand leaf), in other cases the network may be so sparse as to be imperceptible to the naked eye.

The twigs bearing the fungus do not die from its presence. They seem to be injured only indirectly through the effect of the fungus upon the leaves.

FIG. 22.—Apple twig showing characteristic matting of dead leaves held together by dense growt of mycelium; twigs and leaves densely covered by sclerotia and mycelium.

Leaves bearing the fungus turn brown and die. Since they droop in dying they thus often come in contact with other leaves and the fungus is afforded a ready means of migration to the new victim, which in turn rapidly succumbs. If humid conditions prevail, the fungus grows with great rapidity and vigor between the matted masses of leaves, and fastens the dead leaves somewhat firmly together, thus furnishing one of the distinguishing characteristics of the disease (Fig. 22).

The development of the fungus in early spring has not been studied, but it is clear that the sclerotia are hibernating structures, and that in spring they serve as the initial points for new invasion. The spread of the fungus from point to point is chiefly by means of the ribbon-like structures which serve the purpose so admirably that by mid-summer the uppermost buds are reached and already overlaid by sclerotia ready to carry the invasion on again to another season. The work of the sclerotia is so completely done that rarely, if ever, does the parasite allow the escape of any of the branches originating from a twig upon which the fungus has established itself. Unless saved by outside aid, to be once infected is to be always infected.

In North Carolina this disease has been collected on apple at Horseshoe, Addie, Franklin, Hayesville, Marshall, Murphy, Robbinsville, Sylva, Horseshoe, Bryson City, Fatima, Newton, Eufola, Mt. Airy, Spruce Pine, Rutherfordton, Chimney Rock; on the pear at Slyva; on the quince at Horseshoe. It prevails generally throughout the mountain section of North Carolina, but that it is not limited to the mountains is shown by the fact that specimens with complaints of damage have also been sent to the experiment station from the coastal plain region. Its presence is also known in the mountains of West Virginia and Alabama. The disease occurs with much greater destructiveness in humid localities, such as the mountain valleys where the dew is excessive and morning fogs prevail, and it seems probable that it is of wide distribution where these conditions obtain.

Treatment.—The fungus, wintering in a purely superficial manner upon the twigs and depending to but slight degree upon spores, will probably give way to thorough dormant sprayings. The fact that the disease has not been noted upon sprayed orchards, indicates the efficacy of such treatment.

LEAF SPOTS.

The apple, especially in the western part of the State, is very subject to a leaf spot, the character of which is well shown in Fig. 23. The spots, irregular in outline but roughly circular, are tan colored and dead. The border between healthy and diseased tissue is

very definite, and usually the spot bears a series of more or less concentric lines.

Several of these spots upon a leaf largely diminish its starch producing power and thus injure its value to the tree. When badly spotted the diseased leaves fall and almost complete defoliation not infrequently results, with large injury to the yield in succeeding years. This is one of the worst forms of apple disease occuring in the western part of this State.

The spots are of fungous origin, perhaps one, but probably several, species of fungus being responsible for them.

FIG. 23.—Apple leaf spot, in late stage of development, showing concentric rings.

Treatment.—The leaf spot is readily controlled by thorough spraying with Bordeaux mixture, as is recommended for apple scab.

APPLE RUST.

(*Gymnosporangiose*).

The apple rust may be readily recognized by its characteristic yellowish orange spot on the leaves and more rarely upon the fruit. This spot, yellowish green at first, gradually becomes darker, approaching orange. Upon close examination, the upper surface of

an old spot is seen to bear numerous black pustules, smaller than a pin-hole, while upon the lower surface of the diseased spot there appear rough, wart-like protuberances (Fig. 24). This spot is

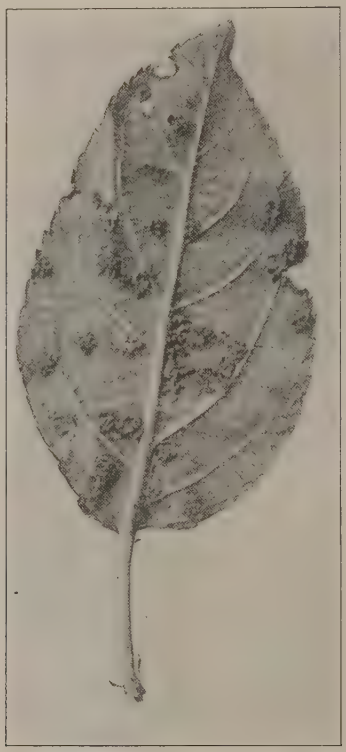

FIG. 24.—An apple leaf affected with apple rust, view from below.

sometimes so abundant that its presence upon orchards at great distances may be recognized by the characteristic hue imparted to the foliage mass as a whole. It is needless to say that such rust of the leaf robs the tree of nourishment and renders perfect fruitage impossible.

This disease is due to a fungus growing in the leaf, and in this case a peculiar relation similar to that exhibited by the wheat rust obtains, in that the fungus spends part of its life on one plant, the apple, and the remainder upon a totally different plant, namely, the red cedar. The fungus summers upon the apple tree or its near relations, the crab apple, cultivated or wild, and toward the approach of winter spores from the apple trees are carried by the wind to

adjacent juniper or red cedar trees. Here the fungus grows and causes what is familiar to every country boy under the name of cedar apple (Fig. 25). The red cedar tree is the *alternate host* of the apple rust.

Fig. 25.—Cedar apple, the winter condition of apple rust as it grows upon the cedar tree.

In the spring the cedar apple sends forth gelatinous horn-like projections, each bearing thousands of spores, which, when conveyed by the wind to the apple tree, may cause the apple rust. Evidence that this relation really exists is easily found if one examines an orchard having one or more red cedar trees upon its windward boundary.

There is much difference in susceptibility to this disease among different varieties. Often some varieties of the orchard rust badly while other varieties are entirely free of rust. Winesap, Gano, Ben Davis, York Imperial and Duchess are especially resistent, while Jonathan, Wealthy, Red June and Whiting are susceptible.

Treatment.—It is evident that the more red cedar trees there are in the neighborhood of the orchard, especially to the windward, the more probability there is of damage from the rust. The rational treatment, therefore, is to remove all these trees if possible.

It is known that in rare instances spores may be carried several miles, but orchards may be rendered reasonably secure if all possibility of infection from the immediate neighborhood is cut off. In case the red cedars are too numerous, or if for other reasons it is impossible to cut them, spraying as recommended for the apple scab will probably lessen the evil though spraying, for this disease gives rather uncertain results.

BITTER OR RIPE ROT.

(*Glomerellose*).

This rot, as its name implies, imparts a bitter taste to the apple

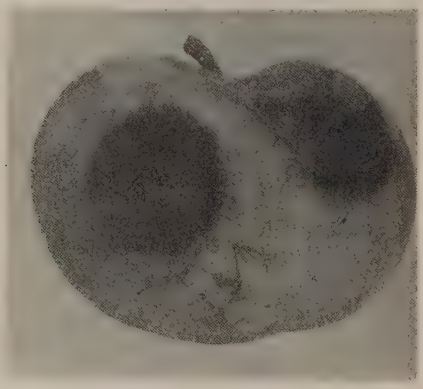

FIG. 26.—Apple ripe rot. Note spore-bearing pustules, especially abundant near the center of the spot.

in the region of the decay. It is found abundantly upon the ripe fruit, although by no means limited to such.

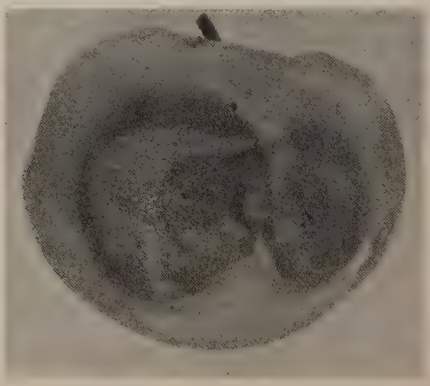

FIG. 27.—Apple ripe rot: somewhat later stage than Fig. 26.

The decayed spots may occur either singly or in considerable number on the apple, and if watched from day to day they may be seen to enlarge rapidly, spreading from the center outwards, thus maintaining a circular form (Fig. 26). As the spot enlarges, small pustules, usually arranged in concentric lines (Fig. 27), appear near the center. As these pustules grow older, they break and assume a pinkish hue, which is quite characteristic of this disease. The rot gradually advances until the whole apple becomes involved, it being changed into a shrunken, worthless mass (Fig. 28).

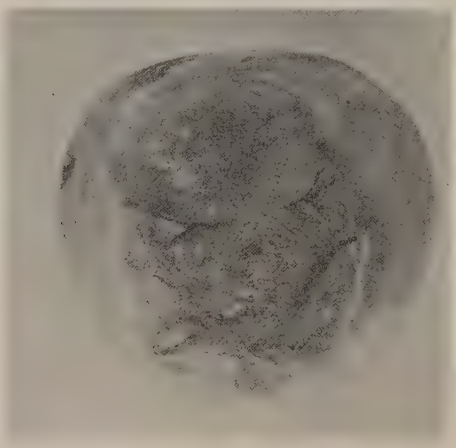

FIG. 28.—Advanced stage of ripe rot.

This disease is of fungous origin. Spores fall upon the surface of the apple, germinate, and penetrating the skin, develop a mycelium in the underlying tissue. The small pustules seen on the surface of the decayed spots are clusters of spores which may be washed off by the first rain, to infect new fruit. That the disease is contagious can readily be proved by inserting a few of these spores under the skin of the healthy apple which will then decay rapidly. Warm, wet weather favors the disease.

This disease is particularly prevalent in the South and has long been of serious damage in North Carolina, although we have no accurate estimate as to the exact injury done. It has been noted in very destructive form in the piedmont and mountain sections, and in many instances is responsible for the failure of the apple crop in these regions. In many cases the entire crop is lost through its ravages. In the State of Illinois in 1900, it was estimated that $1,500,000 worth of fruit was destroyed upon the trees in four

counties alone. Professor Burrill says, "There is no other disease that is so enormously destructive to the apple fruit as the one commonly called the bitter rot."

In 1902, R. S. Simpson and T. J. Burrill, of Illinois, and H. Von Schrenk and Perley Spaulding, of the U. S. Department of Agriculture, independently proved that the same fungus that causes the bitter rot also causes what may be known as the *bitter rot canker* on apple tree twigs.

The bitter rot canker which often starts from a bruise, consists of a sunken bark wound, from two to four inches long, with a ragged border. It is usually found on limbs a half an inch in diameter or larger, though it sometimes grows on smaller twigs. The attack seems to be limited to the bark, as the wood is not injured. Careful inoculations have proved that the spores taken from the bitter rot of the apple cause the canker of the twig, and that spores taken from the canker cause the bitter rot of the fruit. Moreover, in the orchards it is noticeable that early in the season apples suffering from the bitter rot are usually affected first on their upper surface, and that above such affected apples we may often find the apple canker. Indeed, there seems to be complete proof that the infection of each season starts with the canker, the spores being washed down by rain to the apples below. It thus happens that the diseased apples of a given portion of a tree are often arranged in the form of a cone, and that at the apex of this cone is a bitter rot canker, the initial source of infection.

Treatment.—It follows from the relations existing between the apple canker and the bitter rot of the fruit that the same treatment should be employed for each, and that the prevention of the canker means also the prevention of the rot. The orchard should be carefully and systematically inspected and all cankers removed, thus doing away with the source of infection. In addition to this, great care should be exercised at time of pruning and picking, to avoid bruising the bark of the twigs and thus to a great extent prevent the development of the canker on the tree. It is advisable to apply copper sulphate, 1 pound to 18 gallons of water, to the twigs and branches in winter, and to spray as is recommended for apple scab, placing especial emphasis, however, upon that late spraying when the fruit is quarter to half-grown, and substituting ammoniacal copper carbonate or Burgundy mixture for the last spraying in order to avoid spotting the fruit.

BLOTCH.

(*Phyllostictose*).

The blotch, while seriously destructive in some sections of the United States, has not yet injured the fruit in North Carolina to any appreciable extent, though it occurs in abundance upon the twigs

producing small bark cankers. These however have not as yet been injurious.

The presence of the disease upon the twigs may result in an outbreak of the more serious fruit disease at any time that climatic conditions become favorable to the growth of the fungus.

Upon the fruit this disease may be recognized as dark colored spots of very irregular fringed, jagged outline (Fig. 29), a half inch

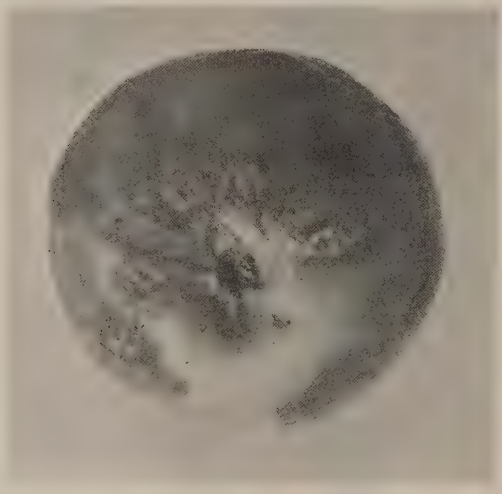

FIG. 29.—Apple blotch. Note irregular boundary of the diseased spots.

or less in diameter. When seriously affected the apple cracks, the cracks reaching even to the core. Minute black pycnidia may be noted in the center of the older spots.

Upon the youngest twigs small tan colored dead spots in the bark appear. These bear numerous small pycnidia. These bark spots are very sharply bordered and are readily recognized from Fig. 30. As the twigs thus affected grow older the spots enlarge to superficial cankers, often several inches long; areas with the bark rough and flaking off.

Treatment.—Four applications of Bordeaux mixture, the first, three to four weeks after the petals fall; the second, four weeks later; the third and fourth, at intervals of three weeks thereafter, are usually sufficient to control the disease. Cankered twigs should be removed and burned.

OTHER CANKERS.

There are several other types of bark wound or diseases which are grouped under the general term of canker. These all have a general resemblance to the bitter rot canker, yet show slight specific

FIG. 30.—Apple blotch canker; at right one year-old twig showing several young cankers; at left, older twig showing more mature, rougher canker.

differences. The injury is at first local, but frequently results later in the death of the affected limb.

Treatment.—As these are caused by fungi which enter through a bruise or injury, three preventive measures are suggested:

1. Destroy cankered limbs to reduce the sources of infection.
2. Avoid bruises and wounds of all kinds.
3. Spray with Bordeaux to prevent germination of spores.

BLACK ROT.

(*Sphaeropsose.*)

This disease of the apple looks very much like the bitter rot, so much like it, indeed, that it would be impossible to distinguish one from the other in an illustration. However, the black rot possesses

a prevailing blackish hue, while the bitter rot, though rarely black, is commonly reddish or pinkish. The spore pustules of the black rot are black, while in the bitter rot they are pink. In other details the two rots closely resemble each other. The black rot is abundant on green apples which frequently fall owing to its attack. Sometimes also it is serious on ripe apples and on fruit in market. The fungus which causes this disease, like the bitter rot, also causes a canker on the bark of twigs.

Treatment.—Methods of eradication should look to elimination of the canker, and spread of the disease should be checked by the use of the Bordeaux mixture.

SOFT ROTS.

There are numerous kinds of soft rots which affect ripe apples in the bin. These are all due to fungi, which effect an entrance into the apple through bruises or breaks in the skin. Once inside the skin, the fungi grow rapidly throughout the fruit, converting it into an impalatable, disagreeable mass. The fungus then proceeds to spore formation, and apples in the latter condition of decay are covered with veritable forests of fungous hyphæ laden with spores. If a healthy apple lies in contact with such an affected apple, it also will succumb.

Treatment.—Very little can be said regarding the protection of fruit from these soft rots, other than to emphasize the need of care to preserve the skin of the apple in sound condition, since bruises or cuts render the entrance of the fungus possible. Cold storage retards the growth of the fungi.

POWDERY MILDEW.

(*Podosphaerose.*)

The powdery mildew is a disease of apples which is of most injury to nursery stock, often becoming so serious as to prohibit successful budding. The use of the ammoniacal solution of copper carbonate as the leaves unfold, and continued at intervals of two weeks until budding time, will effectively prevent this disease.

APPLE SCURF.

(*Phyllostictose*).

This disease was first described in the Thirtieth Annual Report of this Station. It has been under observation for several years, and has been sent to the station with inquiries from two different sections of the State.

The first specimen was received from Watauga County, N. C., in May, 1905. The chief symptom is a shrinking of the bark, including the epidermis, in such manner that minute air spaces are left immediately below the cuticle, giving to the affected region a silvery gray appearance. Close examination, especially with the aid

of a lens, shows the presence of myriads of minute black pycnidia scattered throughout the affected region. Such a condition may extend over large areas on twigs one, two or three years of age. The seriousness of the disease, the amount of damage done, is unknown. That the condition has attracted the attention of practical apple growers to sufficient extent to cause them to submit specimens for diagnosis indicates that the injury is at least appreciable to the apple growers of the State. Death of the infected twigs does not always seem to follow infection. The disease is limited to the bark, and is, therefore, slow to cause death.

Treatment.—Spraying and close pruning of affected branches will probably lead to control of this disease.

BROWN ROT.

(*Sclerotiniose*).

The brown rot upon the fruit, while serious in Europe, has not been destructive in North Carolina, though it has been seen in a few orchards.

The diseased spot turns tan colored, becomes soft and rotten. As the spot ages it becomes coated with a brown fuzzy coat (Fig. 31) similar to that so often seen upon rotting plums or cherries.

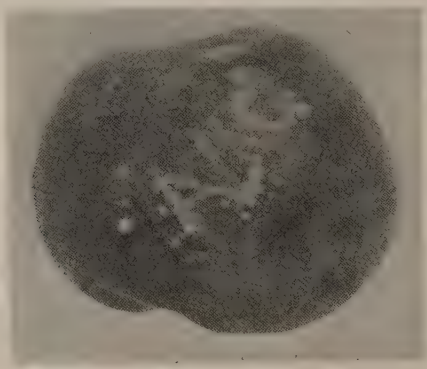

Fig. 31.—Apple brown mould (sclerotiniose). This rot was produced by inoculation. Note that the mould appears forming the letters A. M. C.

No treatment seems necessary. Diseased fruits should be fed to stock to prevent infection in succeeding years.

VOLUTELLA ROT.

(*Volutellose*).

A black rot of apples, closely imitating in appearance that caused by *Spaeropsis,* but differing from sphaeropsose in several details, has been observed frequently in various sections of this State on native apples and on apples shipped into the State.

In general appearance the disease consists of a rotten black spot, the spot increasing in size until it eventually encompasses the whole fruit. The central and older portions of the decayed region are of an intense coal black color. The younger region of the spot, its outer border, a zone about five-eights of an inch wide, is brownish.

Close inspection reveals the presence of slightly elevated pimple-like places in the skin. These are found within about one-fourth of an inch of the edge of the spot, and are larger and more pronounced near the center of the spot, indeed the black color of the spot seems to be due to the thick setting of these black pimples all over its surface. In many instances, unless the spot be quite old, no other development is seen and the disease might readily be mistaken for the ordinary black rot, sphaeropsose, and doubtless often passes for it. In older spots, however, the pimples break through the cuticle of the apple and each pimple appears as a small wart-like excrescence. A good lens then shows that it is thickly set with stiff black hairs. These hairs constitute the distinctive character of this disease and serve to separate it with ease and certainty from sphaeropsose.

On slicing the apple open it is seen that the zone most recently invaded is brownish, while all of the older portion is black (Fig. 32).

FIG. 32.—Volutella rot in section.

While the decayed portions are softer than the healthy, this is in no sense a wet rot, the softness being due to a spongy dryness rather than to any watery breaking down of tissue. Upon microscopic

examination the cells of the old, dark, diseased portion of the apple are found to be filled with a tangled mass of black or dark brown fungous threads (Fig. 33) which are richly septate and much branched.

Fig. 33.—Cell invaded by mycelium.

As the spot ages the mycelium develops more abundantly in a few layers of cells immediately under the cuticle (Fig. 34). From

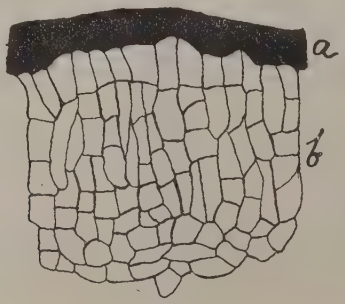

Fig. 34.—Palisade arrangement of hyphæ.

this layer of tangled mycelium there develops a cushion of hyphæ, and from these the sporodochium, characteristic of the fungus (Fig. 35). In these the spores are borne.

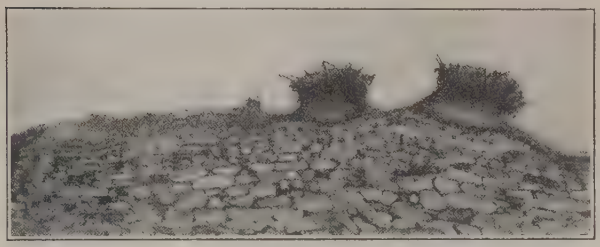

FIG. 35.—Sporodochia in section.

Treatment.—It is probable that the sprayings usually recommended for scab and black rot will be effective in controlling this rot.

FRUIT ROT.

(Coniothyriose).

The rotten spot is circular in uniform tissue, brownish, about the color of the common soft rot, and due to loss from evaporation, the tissue shrinks as the spot ages, leaving the surface much wrinkled (Fig. 36). Distributed somewhat sparsely and irregularly over the

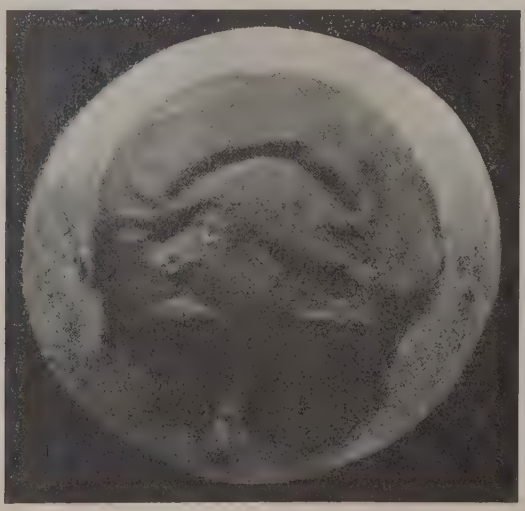

FIG. 36.—Coniothyrium rot.

spot are the fruiting cavities of the fungus (pycnidia). In rotten spots, produced by inoculation, the pycnidia frequently assume a

somewhat concentric arrangement. Proceeding from the innermost pycnidia toward the edge of the spot the pycnidia become smaller, none at all being found near the edge of the diseased tissue.

Upon sectioning through a diseased spot the flesh of the fruit is seen to be rotten, brownish and soft (Fig. 37), not black or dry, as is the case with the volutella rot.

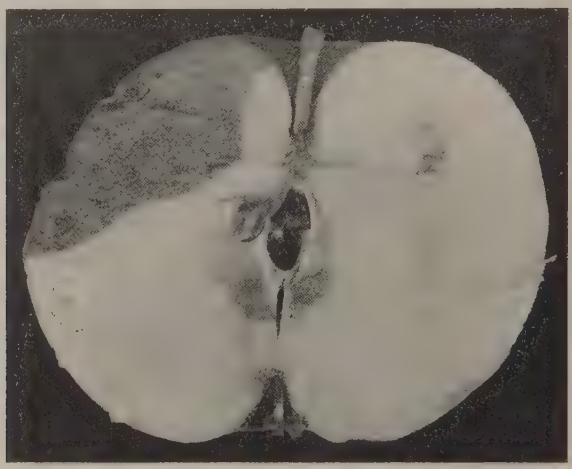

FIG. 37.—Coniothyrium rot in section.

Microscopic examination shows the diseased tissue to be thoroughly invaded with a thin branching mycelium.

When this disease is upon twigs, the terminal portions of recent growth die, the bark shrinks and shrivels, turns black and at the line of demarkation between diseased and healthy tissue cracks (Fig. 38). The general appearance of such a twig is much like that caused by the fire blight, but is readily distinguished by the presence of very numerous, minute, pimple-like pustules, the pycnidia, distributed over the dead part.

The significance of this fungus upon twigs is twofold: (1) As a cause of the twig blight; (2) as a source of infective material, spores, to transmit the rot to the fruit.

Treatment.—Spraying coupled with careful pruning out and burning of diseased twigs and branches will doubtless serve as a means of control of this rot, both of branches and fruit.

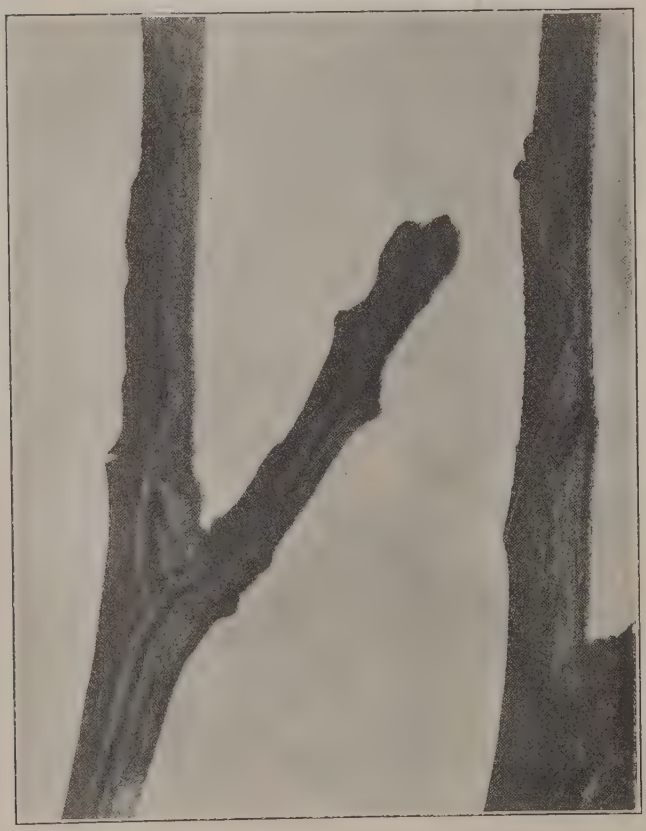

FIG. 38.—Coniothyriose of twigs.

FLY SPECK.

(*Leptothyriose*).

This is well illustrated in Fig. 39.

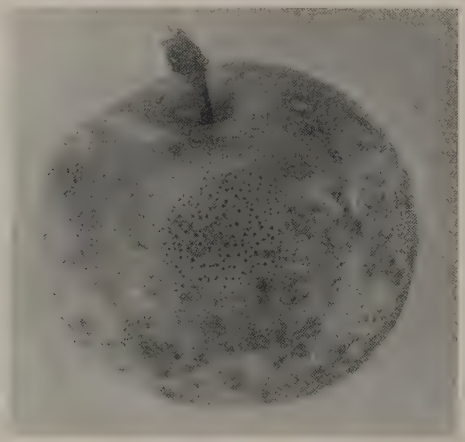

FIG. 39.—Apple fly speck. A superficial fungus of minor importance.

The disease is prevented by the combined spraying given below.

1.—COMBINED TREATMENT FOR APPLE DISEASES.

1. Use all care to avoid bruising bark or breaking the limbs and thus opening the way to canker causing fungi.

2. Use clean culture. Clean up and burn all diseased parts, leaves, fruit, twigs, etc., to lessen infection the succeeding year.

3. Inspect the trees carefully for cankers and blighted parts of any kind; cut them out and burn them to diminish infection.

4. If diseases that winter upon the bark (hyphoenose, etc.) are present, use a dormant spray, Bordeaux mixture, blue stone, or a lime-sulphur wash.

5. Beware of the proximity of cedar trees.

6. Employ spraying mixtures. Bordeaux mixtures 4-4-50 for the earlier sprayings; ammoniacal copper carbonate or Burgundy mixture for the latter sprayings when spotting of the fruit is to be avoided. Spray thoroughly with proper regard for weather conditions.

Spray:

1st. Before the blossoms open.

2d. Immediately after the blossoms fall.

3d. About three to four weeks later.

4th. About four weeks later.

5th. About three weeks later.

6th. About three weeks later.

2.—FUNGOUS DISEASES OF THE PEAR.

BLIGHT.

(*Bacillose*).

The affected tree with its shriveled branches and shrunken, blackened twigs gives the impression of injury by fire. In many cases

b a

FIG. 40.—Pear blight. a, healthy twig; b, characteristically diseased twig.

even whole orchards have succumbed. One pear grower near Washington, D. C., estimated his damage from this one disease in one year at $10,000. The disease is widely known and is present in every county of this State.

During winter the disease may best be recognized by the fact that the leaves of the diseased twigs do not fall as do those of the healthy twigs. In the early spring, when the disease is most aggressive, the blighted twigs are known at a glance by their shriveled, darkened leaves, while on closer examination the black bark attests clearly to the presence of the blight.

This disease has been known since 1780, and affects the apple, quince, hawthorn and plum as well as the pear. It appears sometimes as twig blight, and at other times as flower blight.

Many theories as to the nature or cause of blight have been advanced, among which might be mentioned those depending upon electrical or atmosphere influences, freezing of the bark, too long culture of particular varieties, freezing of the roots, too high culture. insects, absence of needed food and fungi. One of the most prominent among these, put forward by the well-known apple expert, Downing, was known as the "frozen sap theory," according to which the disease was due to the freezing and thawing of the sap, resulting in a loss of vitality and a development of poisons in the tissues. It is unnecessary to discuss any of those theories further than to say that by none of them could all the facts be explained.

In 1878, Burrill discovered in the diseased twig many minute living germs, bacteria. He transferred wood and bark from diseased twigs bearing these germs into healthy twigs and found that the blight was also transferred. Arthur later cultivated the germs for several generations in nourishing substance and then inoculated them into healthy trees and produced the disease. The fact now seems clearly established that it is these bacteria that cause the blight.

We must realize that the bacteria are only about one twenty-five thousandth of an inch long. They grow in the juicy succulent twigs, particularly in the cambium, that juicy part of the stem lying between the bark and the wood. They have no independent means of passing from tree to tree and for transportation are almost entirely dependent upon insect visitors which frequent the diseased twigs in order to secure a sweetish solution which exudes from their surface in drops. These drops are teeming with bacteria, and the insect visitors carry on their feet thousands, even millions, of them which infect the next tree visited. By insects the disease is often conveyed to the blossom, which being an especially succulent and tender portion, furnishes ready access as well as suitable conditions for the development of the germs.

It thus happens that the disease spreads rapidly, doing most damage in spring, owing both to the prevalence then of the succulent stems and branches and to the more ready insect transportation.

It is a matter of common observation among pear growers that trees in too rich soil are more susceptible. This is entirely explainable from the fact that such soil produces a greater amount of succulent, rapidly growing shoots. So too any cause, such as too much pruning, too high fertilization or cultivation, or anything tending to promote too rapid growth, favors the blight. Such conditions are to be avoided, thus lessening the liability to infection; yet this advice must not lead too far, or the tree will suffer from maladies other than the blight.

The proper way to eradicate the blight is to remove the source of infection. To do this, one must remove from the vicinity all infected wood, must cut out and burn all diseased twigs, leaves or branches, either on the pear, apple, quince, hawthorn, plum, or related trees, which might otherwise furnish bacteria for the insects to carry to other trees. If this be done, and done thoroughly, the disease can be controlled. A prominent fruit grower said recently that no man with a sharp knife need fear the blight.

The proper time to cut is whenever affected branches are seen. In the early spring when the diseased foliage is especially easy to recognize, is a favorable time. Subsequent inspection should be made weekly and all blight that is found should be removed. It is well to cut at least a foot below the affected region, since all germs must be removed to secure safety. The greater part of the blight will be removed without difficulty by one thorough fall and spring pruning, but this is useless unless followed up by careful weekly pruning throughout the summer.

Whenever limbs are cut off or bruises made, it is necessary to cover the wound with paint, grafting wax or some other compound (see page 90), to prevent the access of rot-causing fungi and blight bacteria.

If the pruning knife at any time cuts into the diseased wood, it will become smeared with germs. These should be killed by dipping the knife into carbolic acid or corrosive sublimate solutions (1 part to 1000) before cutting again into healthy wood.

ANTHRACNOSE.

(*Colletotrichose*).

This disease was first seen in 1892 by the writer on a pear tree in New Jersey, where it destroyed nearly every fruit on the tree. It is very serious, but fortunately not of frequent occurrence. It has not yet been recorded in this State. In nature, cause and appearance, it closely resembles the ripe rot of the apple (glomerellose), and the treatment is the same as for that disease.

PEAR RUST.

(*Gymnosporangiose*).

The rust of the pear is very similar in nature to the rust on the apple which has been discussed on another page in this bulletin. It consists of two stages, a summer stage and a winter stage. The summer stage produces the rust on the leaves of the pear, while the winter stage forms the familiar cedar apple.

The remedy, as in the case of the apple, consists in removing all cedar trees from the neighborhood of the pear orchard, thus eliminating the source of infection. When this is impossible, the pear trees should be sprayed with the Bordeaux mixture immediately after the early rains which cause the gelatinous horns on the cedar apple.

This disease of pears is particularly abundant upon varieties of the Japanese strain.

FIG. 41.—Pear canker (sphaeropsis). At right the cracked bark of cankered portion. Minute spore-bearing pustules are apparent in certain portions. At left, bark thickly beset with spore-bearing pustules.

PEAR CANKER.

There is a canker (Fig. 41) on the pear closely related to the cankers previously described for the apple. That they are of fungous origin has been proved by many inoculations.

It is probable that spraying the bark with Bordeaux mixture will partially or wholly eradicate this enemy, although no conclusive experiments seem to have been made on this subject

PEAR SCAB.

(*Venturiose*).

The pear scab is familiar to all who raise the pear. It consists of a surface blotch or scab (Fig. 42), often accompanied by a peculiar cracking. This, however, is an effect which is present only in advanced stages of the disease.

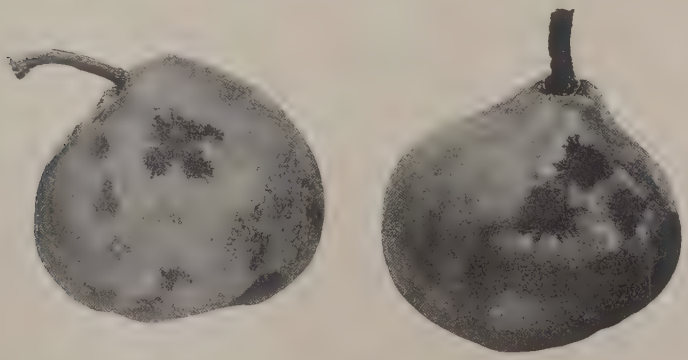

FIG. 42.—Pear scab.

The pear scab is caused by a fungus very similar to that which causes the scab on the apple. Fig 43 shows its microscopic structure.

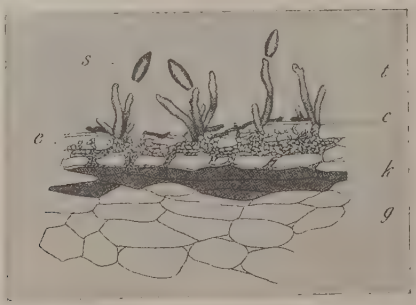

FIG. 43.—The hyphæ of the pear scab fungus-bearing spores.—After Duggar.

The black stalks sticking above the surface are the branches of the fungus, which are to bear the spores, and the three roundish or oval bodies are spores which have just separated from their place of origin. The threads or mycelium of the fungus lie below the skin (*c*) and there take up nourishment, and cause discoloration.

The fungus passes the winter on the bark, as well as upon the diseased fruit and leaves.

Treatment.—This disease has proved amenable to treatment. Results from the Vermont Station show benefit in both quantity and quality from spraying with the Bordeaux mixture, the market value of the fruit being increased from twenty-five to fifty per cent, for example, in case of the Flemish Beauty. In some cases the value of the sprayed crop being placed at one hundred, the crop which was not sprayed brought a value of only forty-seven.

The treatment for prevention consists in spraying to kill the spores and to prevent the development of the fungus. The first spraying should be made before the leaves open, and should consist of copper-sulphate one pound and water eighteen gallons. The Bordeaux mixture should then be used three times: First, just before the blooms open; second, just after the flowers fall, even before all have fallen; third, about two weeks later. The Bordeaux mixture should be of the usual strength, four pounds of copper sulphate, four pounds of lime and fifty gallons of water.

LEAF SPOT.

(*Septoriose*).

The leaf spot, while never completely destructive to foliage or crop, does interfere with the general productiveness and health of the tree by diminishing its green surface. Leaf spot may be distinguished from scab and blight by the fact that the diseased areas are rather sharply defined and characteristically angular in outline Fig. 44). The center of the spot, usually of an ashen color, is surrounded by a brown zone, and this in turn by a purplish one. The ashen center bears several exceedingly minute dark-colored pustules. One of these in section is shown in Fig. 45. The pustule is really a hollow structure bearing numerous worm-shaped spores. Each spore that finds favorable lodgment upon another leaf, is capable of producing the disease.

Treatment.—The treatment recommended for the pear scab is effective in preventing this disease.

LEAF BLIGHT.

(*Fabræose*).

The leaf blight of the pear is almost as widely distributed as is the pear itself. The spot caused by the leaf blight does not exhibit the zonal arrangement described for the leaf spot, and the whole

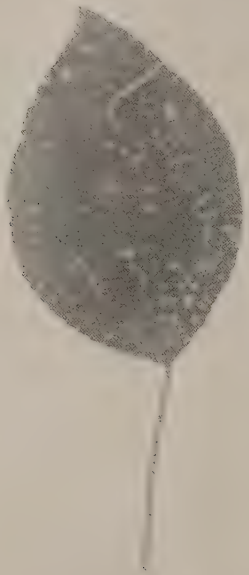

FIG. 44.—Pear leaf spot, septoriose.

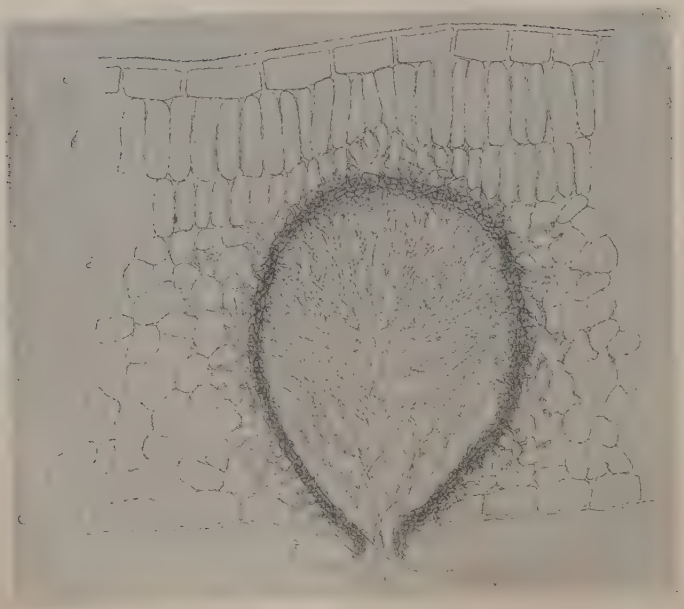

FIG. 45.—Section of a pear eaf showing the leaf spot ungus and its spores.—After Duggar.

leaf more often takes on a diseased appearance, eventually turning yellow or brown and falling. This disease also prevails upon the fruit where it causes a red spot. This soon becomes darker, and may later be accompanied by cracking similar to that of the pear scab. The spores are produced in the centers of the diseased spots, and differ decidedly from the spores of the fungi of the other pear diseases as may be seen in Fig. 46.

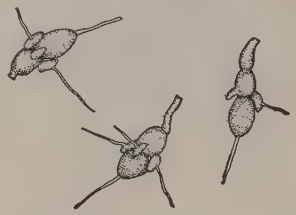

FIG. 46.—Spores of the leaf blight fungus.—After Duggar.

Treatment.—The treatment already recommended for the pear scab will suffice for the pear leaf blight.

HYPOCHNOSE.

This disease, identical with hypochnose of the apple, occurs occasionally upon the pear. The treatment given on page 94 is effective.

3.—FUNGICIDES.

Many plant diseases are caused by fungi, which gain entrance to the plant at the surface by means of reproductive bodies called spores. A fungicide is a mixture which is sprayed upon the surface of the plant, and which by its poisonous properties prevents the spores from successfully germinating and entering the plant.

Spraying for fungous diseases is recognized, by the successful horticulturist as a necessary measure.

BORDEAUX MIXTURE.

This mixture, which takes its name from its place of discovery, Bordeaux, France, is the most widely used and with certain limitations the most effective fungicide. It consists of copper sulphate (blue vitrol or blue stone) and quick lime mixed with water in various proportions.

The chief strengths of Bordeaux mixture are as follows:

4-4-50 BORDEAUX.

Copper sulphate or blue stone	4 pounds.
Quick lime	4 pounds.
Water	50 gallons.

This strength may be used on most plants, the foliage of which is not susceptible to injury.

This formula is recommended for apple, pear and quince.

6-4-50 BORDEAUX.

Copper sulphate or blue stone	6 pounds.
Quick lime	4 pounds.
Water	50 gallons.

This second strength is particularly for dormant trees.

Plants with delicate foliage such as the peach, plum, cherry and apricot require weaker solutions, for example:

2-2-50 BORDEAUX.

Copper sulphate	2 pounds.
Quick lime	2 pounds.
Water	50 gallons.

Or—

2½-6-50 BORDEAUX.

Copper sulphate	2 1-2 pounds.
Quick lime	6 pounds.
Water	50 gallons.

There is no certainty as to which of these strengths is best. To many crops no damage can come from the use of as strong a solution as 6-4-50, yet it is possible that all the protection possible is to be had by use of the 4-4-50 mixture or even by a weaker mixture. If so, there is loss of material by use of the stronger solution. This matter is still open to experimentation.

In the preparation of the Bordeaux mixture, it is well to have on hand stock solutions of copper sulphate and lime. The stock solution of copper sulphate should be made by dissolving a certain number of pounds of copper sulphate in one-half the number of gallons of water, for example: 80 pounds copper sulphate in 40 gallons of water. It is then known that each gallon of this stock solution contains two pounds of copper sulphate, and necessity of further weighing is avoided. The stock solution remains good for any length of time if the water evaporated is replaced. In order to dissolve the copper sulphate, it is best to tie it in a coarse bag and suspend it near the top of the water in a barrel. In this way it will dissolve in a few hours. If it is placed in the bottom of a barrel it will dissolve but slowly, even with constant stirring. It is well to suspend the copper sulphate the night before the mixture is to be made, and it will then be ready in the morning.

In a similar way a stock solution of lime should be made. Quick lime of good quality, which is not at all air-slaked, should be weighed out and placed in a trough and slaked slowly, using a very small quantity of water. By slaking slowly a fine quality of lime is secured. After the lime is thoroughly slacked it should be mixed with enough water to make a putty-like mass. This may be covered with more water to keep out the air and may be used when needed. Since this mass was originally weighed one can estimate near enough the amount needed for any given quantity of Bordeaux mixture.

In preparing the Bordeaux mixture from stock solutions, measure out the proper amount of stock solution of copper sulphate and dilute it with half the amount of water needed in the final mixture. In a similar way measure out the proper amount of lime needed from the stock and dilute it with the other half of the water in a separate vessel.

The lime should be passed through a fine wire strainer of about eighteen meshes to the inch, or through cheese cloth, in order to remove particles of stone, which will otherwise cause difficulty in the nozzle when spraying.

All that remains is to mix these two solutions. They should be poured together slowly and thoroughly stirred.

It is a matter of considerable importance that the stock solutions be diluted before they are mixed with each other. The quality of Bordeaux mixture resulting from this method is superior in several

respects to that which results if strong solutions are mixed together and afterwards diluted.

The Bordeaux should be freshly made each time before using.

SODA OR POTASH BORDEAUX MIXTURE.

While the Bordeaux mixture is eminently successful in preventing many plant diseases, slight difficulty is sometimes encountered owing to the occurrence of small stones, resulting from imperfections in the lime. These, if not thoroughly strained out, clog the spraying nozzle and are troublesome. To escape this difficulty and to render the preparation and application of the Bordeaux mixture easier, as well as to give a mixture suitable for use as the fruit approaches maturity, the use of potash or soda as substitutes for the lime has been recommended.

SODA BORDEAUX.

Copper sulphate (blue stone)..... 5 pounds.
Commercial caustic soda sufficient to combine with copper sulphate and leave a slight excess of soda .... pounds.
Water ..... 50 gallons.

It will be noted that the amount of caustic soda to be used is not stated definitely. It is impossible to make a definite statement, as the strength of the various commercial sodas varies greatly.

The following table, however, gives the amount of copper sulphate required for a single can of several of the more common sodas. In the last column is found the amount of mixture which a can will make. For example, if you choose to use the Champion soda, a can of which weighs 13.73 ounces, you should use 1.6 pounds of copper sulphate to each can of soda. One can of soda contains 12 ounces of substance and the 1.6 pounds of copper sulphate together with the one can of Champion soda will make thirteen gallons of soda Bordeaux.

In a similar way, by consulting the table you may find how much copper sulphate to use per can with any of these brands and how much mixture it will make.

	Gross Weight of Can.	Weight of Substance.	Copper Sulfate Required.	Amount of Mixture.
Soda (Troy)	11.2 lbs.	10.17 lbs.	46.22 lbs.	462 gals.
Babbitt's Potash	17 oz.	14.5 oz.	3 "	30 "
Champion	13.75 "	12 "	1.6 "	16 "
Red Seal	17 "	14.5 "	2.4 "	24 "
Leggett's	17 "	14.75 "	2.5 "	25 "
Lehman's	14.75 "	12.25 "	2.4 "	24 "
Hirsh	14.5 "	12.75 "	1.8 "	18 "
Washington	14.25 "	12.75 "	1.7 "	17 "
Saponifier (Solid)	15.75 "	14.25 "	2.5 "	25 "
Saponifier (Granulated)	17 "	14.75 "	2.6 "	26 "
Natrona	42.75 "	36.75 "	7.2 "	72 "

Dissolve the caustic soda in water. Dissolve the copper sulphate also in water in another vessel and dilute each to half the volume of the completed mixture, then mix the two solutions together.

If put together in the above proportions the mixture will be alkaline. If too little soda is used it will be acid, and it then liable to injure the leaves.

In order that the mixture may be more easily seen on the trees, and thus enable the operator to know when the tree has been completely sprayed, add a small quantity of lime, about one-half pound to every fifty gallons of mixture. This will be sufficient to make a visible deposit on the trunk and foliage of the tree, and enable one to distinguish easily the sprayed from the unsprayed portions.

The strength as given above is really the same as the 5-5-50 Bordeaux mixture. To make one equivalent to the 4-4-50, increase the amount of water by one-quarter.

AMMONIACAL SOLUTION OF COPPER CARBONATE.

This solution contains no sediment and on drying leaves no marks upon the fruit. It may therefore be used upon fruits in the latter stages of their ripening, when the spotting that the Bordeaux mixture causes precludes the use of that fungicide. The mixture consists of a solution made by dissolving copper carbonate in ammonia water in the following proportions:

Copper carbonate	6 ounces.
Ammonia, about	3 pints.
Water	50 gallons.

Weigh out the proper amount of copper carbonate, set a very small portion of this aside and dissolve the remainder of it in diluted ammonia, using only enough to dissolve it and then add the portion of copper carbonate which was reserved. This will insure that you use no more ammonia than is necessary. It is better to have a little too much of the copper carbonate in the solution than to have too much ammonia. A strong solution made in this way can be diluted with the proper amount of water. The copper carbonate may be purchased at any drug store.

BURGUNDY MIXTURE.

Copper sulphate	1 pound.
Sodium carbonate (sal soda)	1 1-2 pounds.
Water	50 gallons.

Each chemical should be dissolved separately in one-half the full amount of water and the two solutions then mixed as in making the Bordeaux mixture.

This non-spotting mixture may be used as a substitute for ammoniacal copper carbonate. It is cheaper and is said to be about equally effective.

Insect poisons should not be added to this mixture.

COPPER SULPHATE SOLUTION.

A solution consisting merely of copper sulphate and water may be used before the leaves appear to kill the spores on the trunks and branches of the trees. It is made as follows:

Copper sulphate	1 pound.
Water	17 gallons.

Dissolve the copper sulphate as you do in preparing the Bordeaux mixture, dilute it to the required strength and spray upon the trees. The addition of a little lime, half a pound to fifty gallons of mixture, enables the operator to see exactly what proportions of the tree have been sprayed.

This mixture must not be used after the leaves appear.

COPPER SULPHATE 1-7.

This is made as above, by using 7 instead of 17 gallons of water to one pound of copper sulphate.

POTASSIUM SULPHIDE SOLUTION.

Potassium sulphide (or liver of sulphur)	1 ounce.

This solution should be freshly prepared. It is used as a substitute for the Bordeaux mixture in the same way as Burgundy mixture, the ammoniacal solution of copper carbonate is used when the fruit has become so large that the Bordeaux mixture must be discontinued to avoid spotting. Potassium sulphide is especially efficient in protection against the powdery mildews.

LIME SULPHUR MIXTURES.

These insecticides (page 61) are also of fungicidal value and when used for insects the Bordeaux mixture of the same date may be omitted.

INDEX.

Ammoniacal copper carbonate 122
Anthracnose 113
Apple, principal insects affecting—
caterpillars affecting foliage 67-73
green leaf aphis 65-67
round-headed and flat-headed borers 52-55
scale insects 58-64
shot-hole borer or fruit tree bark beetle 55-57
woolly aphis 45-51
worms occurring in fruit 73-82
Apple curculio 82
Apple diseases—
bitter rot 98
black rot 102
blight 89
blotch 100
brown rot 104
canker 101
fly speck 110
fruit rot 107
hypochnose 90
leaf spots 94
powdery mildew 103
ripe rot 98
rust 95
scab 87
scurf 103
soft rot 103
volutella rot 104
Apple leaf aphis, green 65
Apple tree tent caterpillar (*illustrated*) 67
Apple twig borer 57
Apple woolly aphis (*illustrated*) 45
Apple worm (see codling moth) 73
Bitter rot of apples 98
Black rot of apples 102
Blight, apple 89
Blight, pear (*illustrated*) 111
Blister mite, of pear leaves 85
Blotch of apples (*illustrated*) 100
Bordeaux mixture, preparation of 119
Borers, in trunk and limbs—
round-headed apple tree 52
flat-headed apple tree 54
shot-hole 55
apple twig 57
Prionus spp. 83

Brown rot 104
Bud moth, eye-spotted 72
Burgundy mixture 122
Canker of apples 101
Canker of pear (*illustrated*) 115
Canker worms 71
Cedar apple rust (*illustrated*) 95
Codling moth (*illustrated*) 73
Copper sulphate solutions 123
Curculio, the plum 80
Curculio, the apple 82
Fall web-worm (*illustrated*) 69
Fire blight—
of apples 89
of pears 111
Flat-headed apple tree borer (*illustrated*) 54
Fly speck (*illustrated*) 110
Fruit rot (*illustrated*) 107
Fruit-tree bark beetle 55
Fungicides 119-123
Green apple leaf aphis 65
Hypochnose, of apples (*illustrated*) 90
of pear 118
Kerosene emulsion, preparation of 50
Leaf spots, of apples (*illustrated*) 94
Leaf spots, of pears (*illustrated*) 116
Leaf blight, of apple and pear 116
Lime sulphur washes 61
Oyster shell scale (*illustrated*) 62
remedial measures 63
Pear, insects affecting 83-85
borers 83
caterpillars on foliage 84
pear-leaf blister mites 85
scale insects 84
worms in fruit 85
Pear diseases—
anthracnose 113
blight 111
canker 115
hypochnose 118
leaf blight 116
leaf spot 116
rust 114
Plum curculio (*illustrated*) 80
Potassium sulphide solution 123
Powdery mildew 103
Prionus borers 83
Ripe rot of apples (*illustrated*) 98
Round-headed apple tree borer (*illustrated*) 52

Rust of apples 95
Rust of pear 114
San Jose scale (*illustrated*) 58
Scab disease of apples 87
Scurf of apples 103
Scurfy scale 64
Shot-hole borer 55
Soda Bordeaux 121
Soft rot of apples 103
Spraying recommendations, general 86
Tent caterpillar 67
Tobacco decoction 49
Twig borer, of apple 57
Volutella rot (*illustrated*) 104
Web-worm, the fall (*illustrated*) 69
Woolly aphis, of apples 45